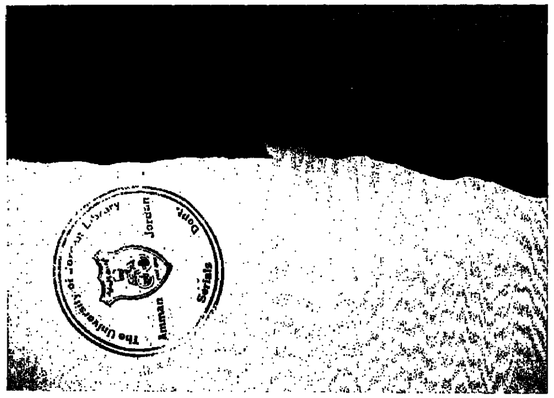

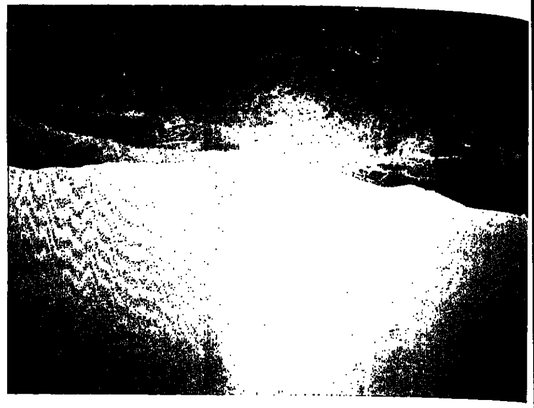

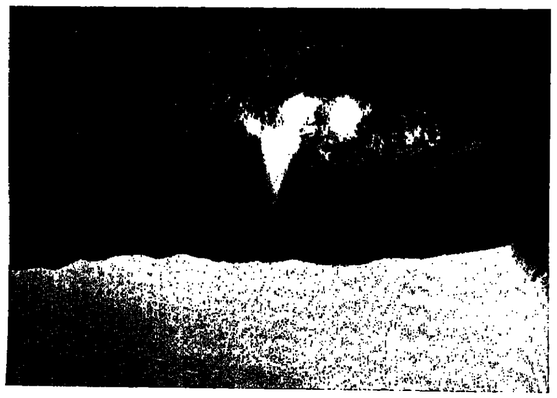

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Seismology

6910 Seismic Sources
SEISMICITY AND ASEISMIC SLIP ALONG THE ELTANIN FRACTURE ZONE
L. M. Stewart (Department of Geological Sciences, Brown University, Providence, Rhode Island 02912), E. A. Okal
The seismic activity of the Eltanin Fracture Zone on the Pacific-Antarctic Ridge for the years 1960-1981 shows that the seismic slip accumulated during this recording interval accounts for only a small fraction (less than 10%) of the amount of slip predicted by kinematic models of plate motion. We propose that the remainder of the plate motion along the transform faults making up the Eltanin system occurs as aseismic creep. This property singles out the Eltanin among transform systems, where previous studies have found good agreement between seismic slip and predicted rates of motion. The absence of record of any gigantic earthquakes and the geometry of the fault zone address the likelihood of the Eltanin rupturing along its entire length. We interpret the Eltanin Fracture Zone in the light of an "asperity" model, involving small, well-separated asperities. Its segmented nature and creeping behavior may be due to the presence of recent magma and, possibly, local spreading, which could also be involved in the mechanism of generation of the Louisville Ridge. (Keywords: Creep, Fracture Zones, Hotspots)
J. Geophys. Res., Red, Paper 3B1073

6950 Seismic Sources
FOCAL MECHANISMS AND DEPTHS OF EARTHQUAKES IN CENTRAL PAKISTAN: A TECTONIC INTERPRETATION
R.C. Quittmeyer (Woodward-Clyde Consultants, Wayne, NJ 07470), A.L. Kafka, and J.G. Armbruster
Focal mechanisms and depths for seven earthquakes in central Pakistan were determined from an analysis of Rayleigh waves of 20 to 50 sec period. In east-central Pakistan, the nodal planes for some solutions strike obliquely to the grain of surface structures. This observation supports the contention of other workers that a thin surficial unit, decoupled from the basement along a surface of decollement, characterizes this region. In west-central Pakistan, relative movement between the Indian and Eurasian plates is at least partially accommodated by seismic slip along the Chaman fault. Other faults, which are situated to the east of and lie subparallel to the Chaman fault, may also take up some of the relative plate motion. Observed activity within the zone of convergent-type structure in central Pakistan may be a result of the greater component of convergence across the Indian-Eurasian plate boundary north of Quetta, Pakistan. (Surface waves, Pakistan, tectonics)
J. Geophys. Res. Red, Paper 3B1512

6980 Surface Waves
MEASUREMENTS OF MANTLE WAVE VELOCITIES AND INVERSION FOR LATERAL HETEROGENEITY AND ANISOTROPY
PART I. ANALYSIS OF GREAT CIRCLE PHASE VELOCITIES
Ichiro Nakanishi (Seismological Laboratory, California Institute of Technology, Pasadena, California 91125), D. L. Anderson
Long-period (100 to 330 sec) fundamental-mode Love and Rayleigh waves have been processed to measure the great circle phase velocities for about 200 and 250 paths, respectively. The observations are treated for horizontal phase velocities, and for an even-order harmonic expansion of the lateral velocity heterogeneity. The regionalized inversion achieves a maximum variance reduction of about 65% and 85% for the Love and the Rayleigh wave data. The 1=2 inversions give a maximum variance reduction of about 60% and 80% for Love and Rayleigh waves, respectively. The 1=4 inversion does not make a large improvement in the fit. The Love wave phase velocities have more power in l=4 and 6, relative to l=2, than the Rayleigh waves. For both Love and Rayleigh waves about the same lateral components dominate the l=2 harmonics, and this component is also strong sectoral components (m=±2), which are approximately in phase with those of the phase velocities. The l=2 harmonics of the non-hydrostatic geoid are dominated by large zonal (l=m=2) and moderate sectoral components. The sectoral components are in phase with those of the phase velocities. The sectoral patterns of heat flow and phase velocity is controlled by high heat flow - low velocity of the East Pacific Rise and western North America, which is reinforced by low velocities in the northwest region (Red Sea - Gulf of Aden - East African Rift). The neotropic low geoid l=2 pattern is dominated by global highs over the western Pacific subduction zones, [illegible]

expansion of regionalized phase velocities shows that they have l=2 variations that are similar to those of the $l_{max}=2$ non-regionalized inversions. This means that the regionalization approach is appropriate as a first step for studying lateral heterogeneity of the Earth. However, the great circle phase velocities are not sufficient, by themselves, to uniquely locate the lateral heterogeneity. The same is true for free oscillation data. (Upper mantle, surface waves)
J. Geophys. Res., Red, Paper 3B1469

Solar Physics, Astrophysics, and Astronomy

7790 Techniques (Phase Correction)
RADIOMETRIC CORRECTION OF ATMOSPHERIC PATH LENG. FLUCTUATIONS IN INTERFEROMETRIC EXPERIMENTS
G. M. Resch (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, California 91109), D. E. Hogg, P. J. Napier
To support Very Long Baseline Interferometric experiments, the Jet Propulsion Laboratory has developed a system for estimating atmospheric water vapor path delay. The system consists of dual microwave radiometers, one operating at 20.7 GHz and the other at 31.4 GHz. The measured atmospheric brightness temperatures at these two frequencies yield the estimate of the precipitable water present in both vapor and droplets.
To determine the accuracy of the system, a series of observations was undertaken comparing the outputs of two water vapor radiometers with the phase variation observed with two connected elements of the Very Large Array. The results show: (1) water vapor fluctuations dominate the residual VLA phase; and (2) the microwave radiometers can measure and correct these effects. The rms phase error after correction is typically 15 degrees at a wavelength of 6 cm, corresponding to an uncertainty in the path delay of 0.25 cm. The residual uncertainty is consistent with the stability of the microwave radiometer but is still considerably larger than the stability of the VLA. The technique is not successful under conditions of heavy cloud. (Atmospheric path delay, Interferometry)
Rad. Sci., Paper 3R1481

Volcanology

8699 Volcanology (Infrasonic Signals, El Chichon)
UTILIZATION OF SEISMICALLY RECORDED INFRASONIC-ACOUSTIC SIGNALS TO MONITOR VOLCANIC EXPLOSIVITY: THE EL CHICHON SEQUENCE 1982, A CASE STUDY
F.J. Mauk (Geophysical Research Department, Weidlinger Geotech, 3405 Shiloh Rd, Garland, Texas 75041)
Infrasonic-acoustic signals from five explosive eruptions of El Chichon volcano during 28 March through 4 April 1982 were recorded by a microbarograph array and SRO seismograph collocated near Mckinney, Texas. Analyses of these signals for frequencies from 0.0033 hertz to 0.025 hertz have demonstrated functional relationships of amplitude to frequency consistent with ω^{-1} for atmospheric data, ω^{-2} for vertical mode seismic data, and ω^{-3} for radial mode seismic data. These observed slopes are in agreement with those theoretically predicted by Sorrells (1971). Estimations of kinetic energy released by the explosions of El Chichon are generated and range from $6.9 * 10^{22}$ ergs to $2.0 * 10^{23}$ ergs for the largest eruption on 4 April 1982 to $4.2 * 10^{21}$ to $6.1 * 10^{21}$ ergs for the smallest eruption of 3 April 1982. The method of Posey and Pierce (1971) to estimate the explosivity from long-period infrasonic signals is not likely to be applicable, strictly speaking, to the SRO seismic period data. There, it is believed that the energy release for the same burst eruption is overestimated by possibly an order of magnitude. Comparable estimations of volcanic explosivity from SRO radial seismic data and microbarometric array data strongly recommend utility SRO (Seismic Research Observatory) and IDA (International Deployment of Accelerometers) network data for far-field analyses of regional volcanic explosivity and construction of a rigorous volcanic explosivity scale. (Infrasonic, El Chichon, Explosive Scale)
J. Geophys. Res., Red, Paper 3B1432

The Geodetic Activities of the Department of Defense Under IGY Programs

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The International Geophysical Year (IGY) programs have special significance to geodesists. The IGY witnessed the launching of the first manmade earth satellite and the beginning of the era of global geodesy. It is no wonder that the U.S. Department of Defense (DoD) with its global geodesy requirements developed an early interest in satellite geodesy. Specifically, this led to the use of early satellites of opportunity (and subsequently of dedicated satellites) for worldwide navigation, geodetic positioning, and gravimetric investigations. In conjunction with other civilian satellite programs under the IGY, DoD played a major role in the achievement of geodetic goals perhaps far beyond that which was envisioned originally. An early satellite program was the project ANNA with the basic concept originating from the DoD. ANNA, a truly cooperative effort, involved the three defense services, NASA, and other civilian agencies. Other examples under satellite programs included many camera and electronic measuring techniques, especially the U.S. Navy's Doppler system, the Army's SECOR, and the pioneering development of laser illuminating and ranging experiments by the Air Force. On this occasion marking the 25th anniversary of the IGY, this article recalls some of the DoD activities of the initial years that fulfilled the geodetic objectives of the IGY and highlights those activities that grew out of the IGY to become today's technology.

1. Introduction

Any discussion of the U.S. Department of Defense participation in the International Geophysical Year (IGY) must begin by recalling the state of geodesy in 1957. Geodetic observations were generally limited to "line of sight." Coordinates of places, say, in North America, were known relative to those in Eurasia to an accuracy of perhaps a couple hundred meters or so. The earth ellipsoid devised by Hayford in 1910 had been named the "International" in Madrid in 1924 and had been used to adjust the European Datum in 1950. The Potsdam determination of absolute gravity and the International gravity formula represented the state of the art in gravimetry.

In the matter of education, prior to 1955, there were no Ph.D.-granting programs in geodesy in the entire western hemisphere. So, it is not surprising that the U.S. Department of Defense (DoD), with its global requirements for geodetic and geophysical information, assumed a leading role in the programs of the IGY. During the ensuing 25 years, DoD has dramatically demonstrated its serious commitment to the enhancement of geodetic and geophysical knowledge on an international scale. There is little doubt that the present day state of the art in geodetic science owes its existence in a large part to the efforts of the U.S. DoD. The long list of technological developments that received their impetus and funding from DoD includes such items as rocket flare triangulation (when we were attempting, in the early days, to tie distant land masses together), the application of lunar occultations and solar eclipses for geodesy, airborne gravimetry, the use of satellites for surveying, the application of inertial technology to surveying, and many others.

The International Geophysical Year (IGY) programs, a truly remarkable scientific enterprise and a cooperative effort shared by over 50 nations, formally began on July 1, 1957. However, some earlier operations such as the loading of U.S. Naval and Air Force aircrafts at McMurdo Sound and the opening of the Amundsen-Scott South Pole Station during October 1956 well in advance of the full-scale IGY were clear indications of the faith, interest, and commitment the DoD in general had in the IGY.

The launching of the first manmade earth satellite in 1957 announced the explosive arrival of the "real" space age in geodesy, and DoD developed an early interest in the resulting infant science of satellite geodesy. Specifically, this led to the use of early satellites of opportunity (and subsequently of dedicated satellites such as ANNA, PAGEOS, GEOS, and the Navy Navigation Satellite System) for worldwide navigation, geodetic positioning, and gravimetric investigations. The activities also resulted in the establishment of DoD's pioneering World Geodetic System (WGS) in 1960, defining a global geodetic network, geoid, and the earth's gravity field model.

In conjunction with other civilian satellite programs under the IGY, DoD played a major role in the achievement of geodetic goals, perhaps far beyond that which was envisioned originally. An early start was the project ANNA. Other earlier satellite programs from DoD also included many camera and electronic measuring techniques, especially the U.S. Navy's MINITRACK and Doppler system (or the Navy Navigation Satellite System, NNSS), the Army's SECOR (or Sequential Collation of Ranges), and the Air Force's PC-1000 camera system. From a conservative objective of a 200-m navigational accuracy, the Doppler system today has become an extremely practical geodetic tool that routinely provides geodetic network control of 1 m or better accuracy over entire continents. And now, the Air Force's latest 18 satellite Global Positioning System (GPS) promises worldwide geodetic accuracies of subdecimeter level.

As part of the overall objective of the IGY gravity program, DoD has always played a major role in the extension and completion of a worldwide network of gravity measurements. From the initial measurement of pendulum bases for control purposes, the DoD effort has been to conduct research and develop better instruments and to aid materially in eliminating the serious gaps in the international network of gravity measurements.

2. IGY Activities

More than 5 years of extensive planning and preparation were devoted to the development of the 1957 IGY programs which were to become a concentration of intense effort to diminish great gaps in our knowledge of the planet earth and its surrounding regions. It should be remembered that the synoptic objectives of these programs also included simultaneous observations in most of the disciplines including polar, weather, solar, and ionospheric programs throughout the world. To achieve simultaneous observations, regular schedules were arranged through international cooperation. To achieve the desired intensification in the observational programs, Regular World Days (RWD) and Special World Intervals (SWI) programs were also designated. The driving motivation was that the resulting concentration of efforts under these programs would be useful in the interpretation of overall results.

If DoD was not in the forefront in every program, it was there contributing one way or the other. Having had direct or indirect experience with these activities, we want to share with you the role that DoD played in the IGY programs.

3. Satellite Programs

The geodetic satellite programs and satellite geodesy grew out of the upper-air rocket research activities, both during IGY and previous years. The Air Force Cambridge Research Center, now the Air Force Geophysics Laboratory (AFGL), Army Ordnance, Naval Research Laboratory (NRL), Navy Bureau of Ordnance, Holloman Air Force Base, Naval Air Missile Test Center, and various U.S. Navy ships (e.g., *The Compass Island*) are some of the DoD components that were in the forefront. Research rockets provided extremely valuable information regarding pressure, temperature, density, and chemical and ionic composition of the atmosphere. They also yielded information about winds, airflow, ionospheric charge density and refraction, solar radiation, and the earth's magnetic field, in addition to being the forerunners of the satellite flights.

The IGY witnessed the launching of the first manmade earth satellite and the beginning of the era of global geodesy. The use of satellites as additional tools in geodetic research and operations was immediately adopted universally, with the official endorsement for such a role coming from the International Union of Geodesy and Geophysics (IUGG) in 1960.

Our interest within DoD started with the use of early satellites of opportunity and then quickly turned into programs for the development of dedicated geodetic satellites such as ANNA.

3.1 *Project ANNA*

With the basic concept originating from DoD in 1958, ANNA (Army, Navy, National Aeronautics and Space Administration, Air Force) was a truly cooperative effort and soon became the testbed for satellite geodetic methods. The extensive research and dedicated efforts of the three defense services, NASA, the Applied Physics Laboratory (APL), and other civilian agencies resulted in the launching of ANNA 1A on May 10, 1962. However, the attempt to place the first "true" geodetic satellite into orbit failed when the second-stage rocket engine did not ignite. Thus, ANNA 1B, launched on October 31, 1962, has the distinction of being the first geodetic satellite.

The basic mission for ANNA 1B was to improve existing geodetic control and to test and compare the performance of other forthcoming systems such as a transponder from the Army's SECOR, flashing lights for the Air Force's PC-1000 camera, NASA's MINITRACK optical tracking system (MOTS) camera, and the National Geodetic Survey's (then U.S. Coast and Geodetic Survey) BC-4 camera and a Doppler beacon for the APL and Naval Weapons Laboratory (NWL) tracking systems.

3.2 *The MINITRACK Systems*

Prior to the launching of U.S. satellites under the IGY programs, NRL had already established MINITRACK stations. The first satellite, Explorer 1, launched in 1958, was a joint venture between the Army Ballistic Missile Agency (BMA) and the Jet Propulsion Laboratory (JPL). The second satellite, Vanguard 1, was sponsored by NRL and the third was again a joint effort of BMA and JPL. These two satellites followed within the next 2 months the launching of Explorer 1.

Even in those early years, the Vanguard satellites were associated with an orbital lifetime of at least 200 years. It was also expected that these satellites with their spherical shape and stable orbits would prove very useful in geodetic and air density studies. Of course, not all those expectations became realities, but the Vanguard IGY satellite program definitely succeeded in laying down a sound foundation for the other projects to follow.

NRL's MINITRACK system became so dense during the early years of this program that it created an electronic "fence" along the 75th west meridian, which every satellite had to cross.

Under the Vanguard 1 satellite program, the comparatively inexpensive MINITRACK Mark II (developed from Mark I) ultimately became operational and was later routinely used by NRL for tracking and obtaining useful data for orbit computations.

3.3 *PC-1000 Geodetic Camera System*

The development for this camera system began near the end of IGY activities at AFCRL. This Air Force system had a lens with a focal length of about 1000 mm, and hence the name. Its chopping shutter allowed observations of the flashing lights from ANNA 1B (section 3.1) or subsequent geodetic active satellites like GEOS 1. This shutter performed equally well with the passive satellites such as ECHO or PAGEOS, which followed later. The PC-1000's were complemented and augmented by the BC-4 camera system employed by the National Geodetic Survey (then Coast and Geodetic Survey).

These cameras were utilized for long range space triangulation for global/continental geodetic control networks. One such network, extending from Curacao to Asuncion, which can be commendably mentioned here, provided much needed control over South America.

3.4 *Navy Navigation Satellite System*

The concept for the Navy Navigation Satellite System (NNSS) or the Doppler system became a reality in 1958. By 1959 the experimental satellite TRANSIT 1A and five tracking stations had been designed and constructed.

Although the TRANSIT 1A satellite failed to achieve orbit, a full development program for the system officially began in 1959. The program's success started with the next satellite TRANSIT 1B (launch date of April 13, 1960) and continued with followups like transit 2A, 3B, 4A, 4B, 5A, etc. The Doppler system witnessed another threshold with the generation of new drag free satellites, the first of which was NOVA 1 (launch date of July 1981). The accuracy improvement has been phenomenal from the modest goals of about 200 m of the earlier years. The Doppler system of today has become one of the most efficient, accurate, and practical geodetic tools for routinely providing geodetic control of 1 m or better accuracy, both for individual stations and/or as part of a station network that uses ground equipment such as the geoceiver.

3.5 *Geodetic SECOR System*

The concept for this system also originated near the end of the IGY years and the first transponder went into space with ANNA 1B (section 3.1). The system was based on the solution of a ground-based four-station tracking pyramid with the satellite transponder as the vertex in space. Over the duration of the SECOR system, an equatorial belt of tracking stations was established. Many of the stations were collocated with BC-4 stations, thus providing additional scale to the PAGEOS network.

After the first SECOR transponder was carried in ANNA 1B, the Army launched additional high and low altitude satellites for the SECOR system between 1964 and 1970. The system was then phased out owing to the high cost associated with the operational methods.

3.6 *Other Systems*

The first Baker-Nunn camera of the Smithsonian Astrophysical Observatory was installed at Organ Pass, New Mexico, on November 15, 1957. Shortly thereafter the U.S.-IGY program established 12 worldwide Baker-Nunn tracking stations. In this extensive optical tracking program, DoD was there to provide valuable logistic and operational support.

The 1959 Iota satellite was placed in orbit by the Army Ballistic Missile Agency as a contribution to the 1959 extension of the IGY, the International Geophysical Cooperation 1959. It turned out to be the last satellite of the IGY programs. The vital initial tracking of 1959 Iota was accomplished by U.S. Army Microlock stations in the United States and Bermuda.

Another satellite program worth mentioning was NRL's Solar Radiation Measuring Satellite or "Sunray." This satellite was carried in a "piggyback" mode with the TRANSIT IIA vehicle of the Doppler system. Although the project was of primary interest to geophysicists, the ionospheric research also contributed information of value for geodesists about accurate orbit computations.

4. Satellite Geodesy

If the concepts and the groundwork for the era of satellite geodesy had been laid before the IGY years through research rockets, the results of geodetic importance came after the launching of the first manmade earth satellite. It was the team of DoD scientists headed by John O'Keefe in 1958 that determined the first definitive result of 1/298.3 for the earth's flattening by using the Vanguard satellite.

From the investigations regarding variations in the orbit of Vanguard 1, DoD was again in the forefront to suggest a modification to the traditional concept of the earth as a rotational ellipsoid. The calculations established the existence of a third zonal harmonic, which in turn required a triaxial ellipsoid with an elliptic geodetic equator and the earth's shape somewhat resembling a pear.

Even if the geodetic activities under the IGY did not provide all the solutions, the research originating under IGY programs became the foundation of achievements that followed in later years. A striking example here would be the NNSS or the Doppler effort. It would be impossible, in the allocated time and space, to describe adequately the achievements in this area. However, once the navigational requirements were satisfied, TRANET observations of the Doppler shift were utilized over the years for continuous improvement of our knowledge of the geo-

Article (cont. on p. 596)

Owen W. Williams received his B.A., with honors, from Kalamazoo College, Michigan, in 1948 and completed postgraduate studies at George Washington University, Washington, D.C., in 1951. He has served as a visiting lecturer in Earth Sciences in Europe and Scandinavia, and in 1967 he was guest lecturer on "Cosmic Geodesy" at the request of the Soviet Academy of Sciences. He retired from the U.S. Government in August 1982, having served in numerous progressively responsible positions culminating as Deputy Director, Management and Technology, for the Defense Mapping Agency (DMA), the highest civilian position in DMA. He has authored over 45 scientific and technical papers, which have been published in national and international journals in the fields of geodesy, gravity, and geophysics.

Kenneth I. Daugherty received a B.S. in mathematics, geography, and geology from Morehead State College in 1957; an M.S. in geodesy from Ohio State University in 1964; Filoosofie Licentiate in 1972; and a Ph.D. in geodesy in 1974 from Uppsala University. He joined the Air Force Aeronautical Chart and Information Center in 1957 and held a variety of line and staff positions there. During this time he worked on pioneer efforts to establish the role of geodetic and geophysical support for ballistic missiles and was a member of USAF Science Advisory Board ad hoc group on geodesy and geophysics. From 1967 to 1974 he was associate professor of geodesy and assistant director of the Hawaii Institute of Geophysics, conducting research in physical geodesy, satellite geodesy, and marine geodesy and geophysics. During 1971–1972, he was a student and a visiting scientist at Geodetic Institute, Uppsala, Sweden. In 1974, he joined the Defense Mapping Agency as chief, Department of Geodesy, DMA Topographic Center. From 1975 to 1978 he was on Headquarters DMA staff. Since 1979 he has been the technical director of the DMA Hydrographic/Topographic Center. Kenneth I. Daugherty is assistant-secretary of the International Association of Geodesy. He is recipient of the USAF Meritorious Civilian Service Award and the DMA Distinguished Civilian Service Award.

The VGP News

"Mind and Mallet and Crucible"
[Originally appeared in *The Geochemical News*, 9, 5, 1958.]

Editor: Bruce Doe, 11721 Dry River Court, Reston, VA 22091 (telephone 703-860-3170, after 5:30 p.m.).

News & Announcements

Travel Grants to IGC

The U.S. National Committee for Geochemistry is seeking funding for its Travel Grant Program to the 27th International Geological Congress to be held in Moscow August 4–14, 1984. In cooperation with other organizations, the committee seeks to ensure appropriate U.S. participation by providing 10–20 travel grants to enable geochemists residing in the United States to attend. Travel grants are to be awarded based in part on a screening subcommittee's ranking of abstracts submitted for presentation at the congress. Special consideration will be given to younger geochemists and those judged to benefit most by participating in this important international congress.

To apply, send six fastened-together sets of completed applications, including completed form and abstract (900–1200 words) of paper to be presented, to W. L. Petrie, USNC/Geochemistry, NAS-NRC, 2101 Constitution Ave., Washington, DC 20418 by January 31, 1984. (Forms available from Petrie.) Travel grantees must use U.S. flag carriers wherever possible and must file a meaningful trip report before October 14, 1984.

Depending on the availability of funds, travel grant awards may be made by May 1, 1984. However, cancellations and other factors may delay a few grant awards to as late as August 1, 1984, or possibly after the congress.

Research Grants Announced

Krueger Enterprises, Inc. has announced the winners of its 1983 Geochron Research Competition. Two awards were granted to support research proposals in each of the following areas: K-Ar dating, C-14 analyses, and Stable Isotope Ratio Analyses (SIRA).

Winners in the K-Ar dating area, their school, and their research topics are James J. Hardy, Jr., Northern Arizona Univ., The use of the K-Ar method to date a major thrust event in west-central Arizona; and Christopher S. Lynnes, Univ. of Michigan, Correlation with age of magnetization in Cambro-Ordovician intrusives from Colorado.

In C-14 analyses: Kee Hyun Kim, Florida State Univ., Cross-check of uranium-series disequilibrium ages by radiocarbon dating: Marine phosphate nodules and their associated sediments; and Charles K. Paull, Scripps Institution of Oceanography, The origin of stratigraphic offsets in deep-sea cores.

In SIRA: Teofilo A. Abrajano, Jr., Washington Univ., Origin and significance of sulfide phases in selected mantle assemblages; and Virginia B. Sisson, Princeton Univ., Oxygen isotope work on the Ponder pluton and associated rocks.

According to Krueger, the awards, which amount to about $1500 worth of analytical services for use in the research, are to be made again in 1984 in the same three areas as well as in Rb-Sr or U-Pb analyses. More information may be obtained from Krueger Enterprises, Inc., 24 Blackstone St., Cambridge, MA 02139 (telephone 617-876-3691).

Meetings

Cosmogenic Radionuclides

Cosmic rays interact with the earth's atmosphere and surface to produce the "cosmogenic" nuclides. In many instances the radioactive ones are readily distinguished from the anthropogenic and meteoritic backgrounds. Measurements of these cosmogenic radionuclides (RCN) can contribute to the solution of a variety of geophysical problems [*Lal and Peters*, 1967]. Recent progress in this area was discussed at a symposium entitled Application of Cosmic-Ray-Produced Nuclides in Geophysics held May 30, 1983, at the AGU Spring Meeting in Baltimore (see *Eos*, May 3, 1983, pp. 282–284, for the abstracts). We summarize here the symposium presentations.

The RCN accumulate differently in different terrestrial reservoirs. Table 1 shows some estimated global production rates and abundance levels for selected samples. In relatively simple collectors such as ice, the measurements may shed light on variations in production rates. In other collectors such as manganese nodules the observations may tell more about the object than about cosmic rays. Accordingly, we divide the following text into two sections. The first summarizes symposium contributions that emphasized cosmic ray histories and the second those that focused on the sample. Where the distinction blurs, the two sections overlap.

TABLE 1. Cosmogenic Radionuclides In Selected Samples

Isotope	$t_{1/2}$, years	Production rate, atom $cm^{-2}s^{-1}$	Sample	Concentration, atom g^{-1}
^{39}Ar	2.7×10^2	~5 × 10^{-7}	Seawater	6
^{14}C	5.7×10^3	1.57*	Corals	7×10^9
^{36}Cl	3.0×10^5	1.1×10^{-3}	Groundwater	10^4
			Ice	4×10^3
^{26}Al	7.2×10^5	1.1×10^{-4}**	Tektites	2×10^8
^{10}Be	1.6×10^6	2.1×10^{-2}**	Rain	1.6×10^4
			Soils	$10^7 - 10^9$
			Lavas	5×10^6
			Phosphorites	10^9
			Mn nodules	5×10^8
			Petroleum	5×10^6

*Stuiver [1980].
**Reyss et al. [1981].

Cosmic Ray Variations

The total flux of solar and galactic cosmic ray particles determines the production rates of the RCN. J. R. Jokipii reviewed the types of temporal variability exhibited by the cosmic-ray flux. He noted the absence of large (>3-fold), long-term (10^3–10^8-years) variations that might be associated with galactic processes. Changes in solar activity are known to induce shorter-term variations. Of special interest here are (1) the 11-year solar cycle which normally gives rise to 25% changes in the cosmic ray flux and (2) a "cycle" lasting perhaps 200–400 years during which the flux may increase by a factor of 2 or 3 in response to solar modulation. Superimposed on the above is a cycle of about 10^5 years attributed to changes in the geomagnetic field [*Bucha*, 1967]. Direct observation of the sun has established the 11-year solar cycle and shorter term variations, namely burbling and gusting of the solar wind, Forbush decreases, and solar flares. Measurements of the RCN may supplement these measurements. They take on primary importance as we go further back in time.

^{14}C in Corals

E. Druffel summarized some studies of ^{14}C, especially in corals. The 11-year solar cycle leads to calculated variations in the $^{14}C/^{12}C$ ratio too small to detect with available methods. Variations in $^{14}C/^{12}C$ ratios with a period of 200—400 years have been documented in several laboratories. Druffel has shown that corals that grew during the "little ice age" have elevated ^{14}C contents.

There are three questions now under study. (1) What is the relationship between climate and solar activity as recorded by RCN's? Present evidence is contradictory. (2) To what extent do oceanic circulation patterns influence the $^{14}C/^{12}C$ ratio of the atmosphere? Evidence from corals suggests that the effect is small. (3) Has ^{14}C production and its exchange rate between air and sea changed much over the last 60,000 years? At present, unknown factors cause ^{14}C ages to be 10% younger than U-series ages of Pleistocene samples. The difference could reflect either an increased ^{14}C production rate or a lower partial pressure of CO_2 in the atmosphere.

RCN in Ice

K. Nishiizumi determinations of longer-lived cosmogenic radionuclides in ice. Unlike soils or sediments, ice cores provide samples minimally diluted by stable isotopes that may interfere with measurements. In favorable cases ice cores give sharp temporal resolution, too. On the other hand, the RCN deposition rates can vary in response to atmospheric processes that may be only poorly understood. One way to test the fidelity of an isotopic record in ice is to compare it to one inferred from ^{14}C or ^{18}O studies.

Measurements of both ^{14}C and ^{10}Be in the Dye 3 ice core correlate well with sunspot activity subsequent to 1950. The ^{10}Be contents vary by a factor of two. Carbon-14 contents change less because the isotope's longer atmospheric residence time damps oscillations due to production rate variations. For the period prior to 1950 agreement between the ^{14}C and ^{10}Be sunspot records deteriorates for unknown reasons. Raisbeck et al. (1981) analyzed ^{10}Be in the Dome C ice core and found that samples deposited during the Maunder minimum had elevated ^{10}Be contents as expected. *Raisbeck et al.* [1981] and Oeschger and coworkers have reported increased ^{10}Be concentration during the last ice age. The ^{10}Be profiles correlate well with ^{18}O results. It is not known whether the enhanced ^{10}Be deposition reflects lower precipitation rates, changes in atmospheric circulation patterns or a higher production rate.

Finally, Nishiizumi summarized recent progress in the $^{10}Be/^{36}Cl$ dating of ice samples. Relative ages for two samples A and B can be calculated by assuming a constant $^{10}Be/^{36}Cl$ ratio in precipitation and the absence of radionuclide transport in ice. With the adoption of a modern $^{10}Be/^{36}Cl$ atom-atom ratio of 8, Nishiizumi concludes that near-surface ice from the Allan Hills region of Antarctica has an age of about 5×10^5 years.

^{10}Be in Lake Sediments

M. Wahlen reported the ^{10}Be contents of varved sediments from two New York State lakes with minimal bioturbation. The purpose of the study was to search for long- and short-term variations in the rates of production. The ^{10}Be fluxes calculated for Green Lake are divided into three periods: a baseline period with low deposition rates (0.016 atom cm^{-2} a^{-1}), a period of enhanced rates during the Spörer and Maunder minima (up to 0.1 atom cm^{-2} a^{-1}), and the last 200 years or so during which ^{10}Be fluxes have steadily climbed toward a value near 0.8 atom cm^{-2} a^{-1}. The observations for the second period match in size but not in temporal detail similar results from ^{14}C. The recent increase in ^{10}Be deposition is attributed to increased soil erosion.

Sample Oriented Studies

^{10}Be in Rainfall

Deposition rates for the longer lived RCN are not yet well known. *O'Brien* [1979] calculated a global average production rate of 0.025 atom cm^{-2} s^{-1} for ^{10}Be, while *Reyss et al.* [1981] estimated 0.021.

G. J. Stensland and M. C. Monaghan independently presented the results of several determinations of ^{10}Be in rainwater. The authors designed the experiments to learn more about the factors influencing ^{10}Be deposition. Stensland's group deployed traps open only when rain fell. At one site (Bondville, Ill.) the average monthly fall-out rate ranged from about 1×10^4 to 2×10^4 atom ^{10}Be g^{-1} H_2O. Values were highest from May to August and lowest from October through March. The variations parallel those observed for ^7Be. Stensland noted that the Ca contents of the rainwater samples indicate contamination by fine soil particles. Raindrops or wind presumably lifted these particles into the air where they were entrained by raindrops on their way to the collectors. The concentration of ^{10}Be in the soil particles was not measured directly. Stensland estimates the contribution from this source may be as high as $\sim 1 \times 10^7$ at ^{10}Be g^{-1} H_2O. This work demonstrates the need for care in the collection of samples.

Monaghan attempted to estimate the annual global production of ^{10}Be from measurements of ^{10}Be and ^{90}Sr in rainwater. Each sample consisted of a year's precipitation collected at one of eight sites in the United States. Dust may have contaminated some samples. The observed, latitude-dependent fluxes of ^{10}Be were normalized to global ones with the aid of the ^{90}Sr measurements and the known global deposition rate of ^{90}Sr. With various assumptions and a theoretical correction for tropospheric production Monaghan obtains a global production rate of about 0.018 at ^{10}Be/atom cm^2. From a comparison of the different sites, Monaghan concludes that the ^{10}Be flux as measured by precipitation at a particular location may not reliably reflect the ^{10}Be production rate.

^{39}Ar in Seawater

R. D. Willis presented the first profile of ^{39}Ar in seawater. The ^{39}Ar half-life (269 years) makes this isotope important for treatments of oceanic circulation. The time scale for ventilation of the ocean is now estimated mainly from determinations of the less sensitive ^{14}C. The samples discussed by Willis were collected at depths between 0 and 600 m in the north Pacific (GEOSECS I). Each of the five samples weighed about 2 tonnes (t), was counted for 2 months, and contained on the order of only 6 atom ^{39}Ar g^{-1} H_2O. The ^{39}Ar datum reported for 600 m differs significantly from the prediction of a ^{14}C box diffusion model. Three times lower than the calculated value, the observation suggests a removal rate of ^{39}Ar some 8 times faster than expected. Samples from depths of 4000 m remain to be counted.

Sources of Atmospheric Methane

S. Hameed estimated from the carbon isotopic ratios measured in atmospheric methane the fraction of methane derived from (1) the incomplete combustion of fossil fuels, (2) the partial burning of biomass, and (3) bacterial sources. Biomass burning may be more important than previously realized.

^{10}Be in Lavas

L. Brown discussed progress in studying ^{10}Be in volcanic rocks. The primary purpose of this ongoing work is to demonstrate that island-arc lavas contain measurable traces of pelagic sediments subducted from the sea floor. Semiquantitative estimates of the fraction of sediment-derived material present in a sample may then be possible. ^{10}Be acts as a good tracer for sedimentary matter for the following reason: Ocean sediments may contain up to 10^{10} atom ^{10}Be g^{-1} while igneous rock more than a few million years old should have virtually none. In the last year Brown and his colleagues have doubled the number of analyses of volcanic rocks, bringing the total to about 40. The experimenters took pains to try to minimize contamination from soil and rain. They divide their results into three groups. Twenty of 21 samples from the Aleutians and Central America contain between 2×10^6 and 5×10^6 atom ^{10}Be g^{-1}. In contrast, 10 non-island arc lavas and flood basalts have less than 1×10^6 atom ^{10}Be g^{-1}. Island arc samples from the Andes and the Far East seem to constitute an intermediate group: Most have low ^{10}Be contents but a few are similar to the Central American lavas. Brown prefers to defer comparisons of ^{10}Be with other elements until the ^{10}Be systematics are more firmly established. For the present he concludes that island-arc lavas do indeed contain ^{10}Be that once resided in pelagic ooze.

^{10}Be in Phosphorites, Mn Nodules, and Petroleum

C. Tuniz reported measurements of ^{10}Be in marine phosphorites. The aim of the study was to learn more about the timing of phosphorite formation. W. C. Burnett and H. H. Veeh have argued in several publications that U-Th disequilibrium dating supports a recent (<2 × 10^5 years) origin for certain phosphorites collected off the coasts of Chile and Peru. Others have questioned this conclusion. Tuniz and coworkers showed that (1) phosphorites contain about 2×10^9 atom ^{10}Be g^{-1}, about twice as much as nearby sediments and (2) laminated phosphorites with ^{234}U-^{230}Th top-to-bottom age differences of a few thousand years have no ^{10}Be variability within experimental error as would be expected if the ^{234}U-^{230}Th ages were valid. Two kinds of blanks were discussed. Five million-year-old phosphorites from Bone Valley, Fla., have low ^{10}Be contents, consistent with radioactive decay, leaching, or a low initial complement of ^{10}Be. It remains to be seen whether very old submarine samples contain ^{10}Be from water-borne infiltration. A negative finding would strengthen the case for recent phosphorite origin.

Several groups have exploited acceleration mass spectrometry for the measurement of ^{10}Be and other cosmogenic radionuclides in manganese nodules and crusts. The results may be used to calculate growth rates; they may also give information about the conditions under which deposition occurred. A. Mangini and coworkers studied a manganese crust some 20–40 cm thick dredged from a depth of 4830 m in the central Pacific. They measured the ^{10}Be and metal contents of 18 samples. A plot of ^{10}Be by depth suggests a two-stage accumulation history: an early one lasting from 11 to 6 m.y. B.P. with a deposition rate of 4.8 mm/M^y and a late one with a slower deposition rate of 2.7 mm/m.y. The shift at 6 m.y. B.P. may coincide with a discontinuity in the δ ^{13}C record noted by others. With the aid of the growth rates, Mangini calculated dates for several petrographic and chemical changes observed in the crust. Many of these events apparently coincide with changes in paleoceanographic circulation inferred independently from the study of deep-sea sediments. Mangini concludes that the compact Mn nodules and crusts can provide paleoceanographic histories.

Motivated by the lack of reliable isotopic techniques for the age-determination of petroleum, F. Yiou and coworkers have begun a survey of ^{10}Be in various petroleum reservoirs. Oils older than 25 m.y. contain no detectable ^{10}Be; crude oils thought to be 2–5 m.y. old have detectable quantities of ^{10}Be, 4–9×10^6 atom g^{-1}; a modern, hydrocarbon-rich sediment contains 4×10^7 atom ^{10}Be g^{-1}, some of which may attach to the clastic component. The authors note that many factors may influence the ^{10}Be contents of crude oils, among them initial deposition conditions, exchange with water, sediments, reservoir rocks and kerogen, and migration history.

^{10}Be in Soils

M. Pavich and J. Klein both reported on ^{10}Be measurements in soils. The multiple origins of soil particles pose a difficult problem for isotopic dating of samples more than 10^5 years old. It has been suggested that with suitable modeling, ^{10}Be measurements may provide useful information about soil chronology. Pavich measured the ^{10}Be contents in soil columns from Merced River, Calif., terraces ranging in age from 0.04 to 3 m.y. As expected, total ^{10}Be inventories increase with column age and thickness. For the oldest columns, however, the standing crop of ^{10}Be falls short of the amount anticipated based on current estimates of the deposition rate and the assumption of complete retention. From the shortfall the authors estimate a ^{10}Be residence time of 6×10^5 years. *Monaghan et al.* [1983] obtain a lower value of about 10^5 years from an analogous study of other soil columns. Whether the discrepancy arises from sampling artifacts or site-specific differences is not resolved. Pavich notes a correlation between clay and ^{10}Be contents in the soils.

Klein and coworkers have been studying erosion in various watershed regions by applying mass balance to ^{10}Be. They measure the ^{10}Be contents of sediments from rivers or on continental margins, multiply by the sediment flux, and compare the result with the fall-out rate of ^{10}Be over the watershed. In a few cases such as the Amazon and the Susquehanna rivers, ^{10}Be inflow and outflow match to within a factor of 2. In many others such as the Mississippi and Yangtze rivers, ^{10}Be loss may exceed accretion by as much as a factor of 10. No "primordial" watershed has been found to give a steady-state for ^{10}Be. Thus, increased erosion due to agriculture may account for part but need not explain all of the net loss. Klein notes that, with a few exceptions, areas with the highest erosion rates produced sediments with the highest ^{10}Be contents. The authors conclude that erosion tends preferentially to carry away particles rich in ^{10}Be.

^{36}Cl in Groundwater

The relative inertness of aqueous Cl^- renders it especially suitable as a hydrologic tracer. Groundwater contains $^{36}Cl^-$ derived from three main sources: cosmic ray bombardment of the air and of rocks, activation of rocks by fission-produced neutrons, and bomb-testing. With appropriate modeling the ^{36}Cl contents of groundwater systems give chronological and hydrodynamic information. Accelerator mass spectrometry makes it possible to measure the low levels of ^{36}Cl encountered. S. N. Davis, H. W. Bentley, and P. L. Airey discussed the application of ^{36}Cl measurements to the study of the Great Artesian Basin in Australia and to the Milk River Aquifer in Alberta, Canada.

In the Great Artesian Basin, $^{36}Cl/Cl^-$ ratios decrease systematically from the source to the discharge region. With minor exceptions, the isochrons mapped from the ^{36}Cl ages agree well with isochrons independently calculated from the known hydraulic parameters of the system. The authors interpret the agreement as a strong endorsement of the assumptions of ^{36}Cl groundwater dating.

The Milk River Aquifer behaves differently: Cl^- and ^{36}Cl contents increase with distance from the recharge or source region, while the $^{36}Cl/Cl^-$ ratio decreases. The authors interpret the concentration increases in terms of "ion filtration." The $^{36}Cl/Cl^-$ ratios yield water ages that exceed estimates from numerical modeling, perhaps because glaciation interrupted the flow patterns for long periods of time. Some dilution of ^{36}Cl by contemporary dissolution of ancient chloride deposits may also occur. This process, too, would increase the calculated ^{36}Cl ages.

^{10}Be & ^{26}Al in Impact Ejecta

The application of cosmogenic radionuclides to the study of impact-produced materials was discussed by G. Raisbeck and F. Tera. Last year *Pal et al.* [1982] showed that australasian tektites contain ~2 × 10^8 atom ^{10}Be g^{-1}. They argued that the ^{10}Be and the tektites formed on earth, but could not entirely exclude the possibility that a small extraterrestrial component, either lunar or meteoritic, carried some ^{10}Be. If the ^{10}Be were extraterrestrial, however, the tektites would also have to contain measureable quantities of other cosmogenic radionuclides such as ^{26}Al and ^{53}Mn. Raisbeck used accelerator mass spectrometry to measure the ^{26}Al contents of several australasian tektites and other impact-related objects. The $^{26}Al/^{10}Be$ ratios observed were consistent with a terrestrial but not an extraterrestrial origin. These observations unambiguously rule out a lunar origin for tektites. Raisbeck also found that other impact-produced materials such as Libyan desert glass contain ^{26}Al in amounts consistent with what cosmic rays would produce on bombarding terrestrial surface matter for ~10^7 years. He suggested, as have others, that the cosmogenic radionuclides may prove useful in the calculation of surface exposure ages of terrestrial rocks.

Tera presented the ^{10}Be contents of more than 20 australasian tektites and the ^{26}Al contents of six. Again the $^{26}Al/^{10}Be$ ratios were terrestrial. Tera stressed the small range of values observed for ^{10}Be, values which average about 2×10^8 atom ^{10}Be g^{-1}. Sediments harvested from continental margins exhibit a similar, small range of ^{10}Be contents. Soils, in contrast, have ^{10}Be contents that differ markedly from location to location, ranging from 1×10^7 to over 10^{10} atom ^{10}Be g^{-1}. Tera suggests a continental margin for the site of the impact that produced australasian tektites. An origin on a continental margin would accommodate the difficulty specialists have had in identifying a source crater: the crater would have been covered. A margin site may also furnish material from considerable depth with appreciable ^{10}Be content and thus would help explain the uniformity of the data.

Prospects

The advent of accelerator mass spectrometry has greatly facilitated the measurement of such long-lived β-emitters as ^{36}Cl, ^{26}Al, ^{10}Be, and ^{129}I. The new technique obviates the need for fastidious radiochemistry, reduces to 1000 times the minimum sample masses, and gives results in hours rather than days or weeks of counting. Technical advances continue. D. Elmore pointed to prospects for measuring ^{41}Ca and certain stable elements; for example, platinum. Accelerator mass spectrometry may prove helpful in the measurement of solar-neutrino-produced isotopes and in other problems in particle physics that have geologic detectors. Willis outlined progress made by Hurst and coworkers at Oak Ridge in the detection of ^{81}Kr by laser-assisted separation and mass spectrometry. The advance of resonance ionization techniques promises a host of new applications.

K. K. Turekian sounded several cautionary notes. He pointed out that because local deposition rates of the RCN may vary appreciably, certain investigations will require large numbers of measurements to establish clear patterns in the results. The high cost of using the new measurement techniques militates against such surveys except where no cheaper approach exists. Furthermore, gaps in our understanding of the geochemistry of the RCN and of the systems in which they are studied may cloud the interpretation of even the most precise results. For example, diffusion as well as successive laminar deposition may influence the ^{10}Be contents of Mn crusts and nodules.

The foregoing text indicates the wide variety of geophysical problems related to cosmogenic radionuclides. While the less well-known isotopes ^{10}Be, ^{26}Al, ^{39}Ar, ^{81}Kr, and ^{129}I seem unlikely to challenge ^{14}C in importance, they occupy niches that ^{14}C cannot fill. We regard the study of ^{10}Be in volcanic rock as fundamental in importance. The hydrogeological measurements of ^{36}Cl have begun to meet expectations. The analysis of cosmogenic radionuclides in various terrestrial reservoirs augments our knowledge of sedimentary, depositional, and erosional processes. Much of the work described is exploratory. We anticipate that rapid progress in the area will continue.

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This report was prepared by G. F. Herzog, who is with the Department of Chemistry, and T. H. Kruse, who is with the Department of Physics, of Rutgers, The State University of New Jersey, New Brunswick, NJ 08903.

Opinion

Isotope Instrumentation

Editor's Note: The following commentary is excerpted from the second preliminary report on isotopic instrumentation in geochemistry and mineralogy submitted to the Intersociety Committee on Instrumentation in Geochemistry and Mineralogy (ICIGM). The report expresses the opinions of one individual (HRD) and in no way is an official expression of the ICIGM. For a copy of the full report write to Bruce R. Doe, 11721 Dry River Ct., Reston, VA 22091.

Accelerator Mass Spectrometry

The Accelerator Mass Spectrometer (AMS) at the University of Arizona, built by General Ionex on the Cockcroft-Walton principle, is reported by Paul Damon to be operating routinely and well at 1.8 MeV. Radiocarbon ages that match or exceed the best underground beta counting facilities are reportedly being produced. Reproducibility is reported to be 1%, a value Damon feels can be improved as they get more experienced in preparing and mounting samples. A second machine at the University of Toronto—built after the initial University of Arizona instrument—is rumored to be operating at 2.5 MeV and Damon is now checking this out. At Arizona they will now convert to using chlorine-36. The price of the General Ionex machines has risen to about $1.4 million.

Cooperative research with many investigators continues at the University of Rochester tandem Van de Graaf mass spectrometer of which, D. Elmore reports, 20% is funded to do earth science studies. This facility is the most versatile laboratory, with data on chlorine-36 in ice, as well as a variety of beryllium-10 studies, being published. Meyer Rubin has been doing radiocarbon studies there and reports that it is sufficiently well automated that he can run samples by himself so long as nothing goes wrong (i.e., in routine operation, one doesn't have to be an accelerator expert). Analytical uncertainties seem to be about 5% though Rubin feels he is getting about 3% data on radiocarbon. Elmore reports that other kinds of studies are planned such as iodine-129.

The tandem Van de Graaf mass spectrometer at the University of Pennsylvania has been progressing well. Papers by Roy Middleton and colleagues, Lou Brown of the Department of Terrestrial Magnetism (DTM), and Milan Pavich of the U.S. Geological Survey (USGS) and others have involved primarily beryllium-10 in soils and the most exciting paper on volcanic rocks; however, the first application paper by AMS on aluminum-26 has also recently been published. Although this facility is not as well automated as the one at Rochester and must be operated by accelerator experts, R. Middleton is known as the genius of sources (G. F. Herzog of Rutgers University refers to Middleton's "window maker" source as a real advance). Intensity has been increased by a factor of 50 since 1979. As of the time of this report, the University of Pennsylvania/DTM team has yet to sell an earth science proposal to NSF, so all studies so far are "bootlegged" off of particle physics funding but with the knowledge of the funding agency. Small but important support is provided by DTM and the USGS. L. Brown reports that they can have excellent reproducibility on a given day (perhaps 0.1%) but reanalyses a few weeks later may differ by 5%.

Herzog, at the Rutgers University facility has mainly published on extraterrestrial samples but is also interested in lake sediments and pelagic sediments and tektites. As of the time of this writing, he has a grant covering this work.

Time on the Yale tandem Van de Graaf mass spectrometer is severely limited and is bootlegged, but there have been some important papers by Turekian and colleagues on beryllium-10 in manganese nodules. I believe

VGP (cont. on p. 596)

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Cover. Bounded on three sides by water, San Francisco is a delight to travelers and is the site of the annual AGU Fall Meeting, being held this year December 5–9. Housing reservation deadline is November 1. Meeting preregistration deadline is November 10. See Housing and Registration forms in this issue. (Photo courtesy of San Francisco Convention & Visitors Bureau.)

VGP *(cont. from p. 595)*

a thesis on sediments is completed also.

Herzog has pointed out that a tandem Van de Graaf is also operating at the University of Washington (G. Farwell) and that the State University of New York at Stony Brook (A. Champagne) is starting up. I haven't run across any papers from these facilities, however.

A matter that needs mentioning is the itinerant U.S.-non U.S. research efforts. The first paper reporting AMS radiocarbon dates recently appeared in *Science*. This paper was a collaborative effort by a physicist at San Jose State with the AMS group at the Swiss Federal Institute of Technology. T.-L. Ku and colleagues have been doing beryllium-10 studies of manganese nodules with the Toronto AMS group. It appears to be difficult for all the U.S. scientists who wish to participate in the terrestrial cosmogenic radionuclide work to be involved with U.S. AMS facilities, but at least some of those being left out are being resourceful in finding collaborating facilities somewhere in the world. The problem is not restricted to the U.S. scientists. C. M. Raisbeck of France—the person who started it all and had a 2-year head start—has not been able to get on French facilities, so has been collaborating with researchers at U.S. AMS facilities at the universities of Rochester and, more recently, Pennsylvania. Raisbeck is now getting a General Ionex machine, however.

Elmore has pointed out to me that the very important krypton-81 (not formed by spontaneous fission in nature, like chlorine-36) cannot be done by AMS methods because it does not form negative ions. An alternative, laser-based method is being worked on by a consortium involving Scripps, Bern, and Oak Ridge. G. Wasserburg points out that once improved electronics are developed for the Cameca ion probe, it should be ideal for doing aluminium-26, so AMS might not be necessary for it. Therefore, AMS facilities cannot do all the cosmogenic radionuclides, and the relatively less-expensive instruments like the ion probe may be suitable for some others. Although the big tandem Van de Graaf facilities are adequate for the time being to do the first order studies in the frontier scientific area of terrestrial cosmogenic radionuclides, their expense (more than $1000 per day) and lack of high, long-term precision probably will render them unsuitable at some undefined date in the future. The relatively low-cost General Ionex machine is not yet operating at the 5 MeV mentioned in the specs. Alternatives (desk top cyclotrons of Muller, etc.) are not yet developed. Our problem, therefore, is two fold:

(1) We must get funds for terrestrial cosmogenic radionuclide studies, both for scientific investigations and for operation and development of a few existing AMS facilities. Proposals in scientific exploration (where AMS has the best applications) receive hostile peer review in the earth science area of NSF, compared to the normal scientific engineering proposals (where you know a lot and can make a good case for the next step);

(2) We must develop less costly, more precise instrumentation over the next decade.

As bootlegged research and research funded by other agencies or parts of NSF sponsored research by the Physics Division become published and terrestrial cosmogenic radionuclides begin to move into a less pioneering mode, the hostility in the peer review system of the earth sciences community in NSF may begin to evaporate. This development will stress existing NSF budgets in earth science, especially as the interest of the Physics Division can be expected to wane.

I am a little bit uncertain as to what is the proper thing to do for the next step. Certainly I am not competent to render a Delphic decision. I think two things are needed, however: (1) a strategy on how to proceed over the next 10 years or so in this area and (2) some priorities as to where cosmogenic radionuclides should be, relative to the rest of geochemistry and mineralogy.

As for the importance of this research area, I quote from the previous report of June 16, 1982:

> This frontier area of geochemistry is not only exciting—for example, it appears from Be-10 studies that sediments are being subducted in many areas—but has great application to societal goals as well. These applications extend from the dating of mineral deposits (many phosphorite deposits thought to be Recent are gradually shown to be Miocene, but they are difficult to date) to the already mentioned groundwater dating for waste storage to ground stability evaluation. In ground stability, there is the dating of both sediments and sedimentation rates, evolution of soils, and dating exposure ages of target rocks. One of the most difficult dating areas involves torrential flooding and land slides and determination of recurrence intervals. Exposure ages are a good way to get at this if the technique works.

In spite of the difficulties, there are an impressive amount of research, number of players, and variety of research at the four main facilities (but mainly Rochester and Pennsylvania), as testified to by the symposium organized by G. F. Herzog at the Baltimore AGU meeting on May 30 (*Eos*, May 3, 1983, pp. 282–284, and the meeting report in this issue of The VGP News). Papers involving AMS were presented on ^{10}Be in lake systems, ^{10}Be and ^{36}Cl in ice, a beginning on ground water, ^{10}Be in precipitation (2 papers), ^{10}Be in soils and also in erosion and deposition, ^{10}Be in phosphorites and in crude petroleum as well as in a manganese crust and, of course, tektites (2 papers). If I've counted correctly, the symposium involved 36 researchers, some of whom are on more than one paper. The interest is certainly there and should build during the decade.

Bruce R. Doe
Editor, The VGP News

Article *(cont. from p. 593)*

centric coordinates of earth-fixed points, establishment of ties between world datums and determination of polar motion and the earth's gravitational model.

The launching of the first satellite during the IGY and the subsequent launching of dedicated geodetic satellites started a new era of global "datums." DoD was first to solve such a datum in 1960. The solution that became known as the World Geodetic System (WGS) in 1960 thus provided for the first time a "truly" geocentric worldwide coordinate system for global mapping and charting.

5. Gravimetric Investigations

Under the IGY gravity program, DoD played two important roles: first, to participate actively in gravity measurements all over the globe and, second, to provide logistic support to other agencies in remote areas like the Arctic and Antarctic.

The measurement program, besides filling in the gaps where gravity observations were scarce and of doubtful accuracy, included the establishment of first-order stations, the calibration of gravimeters, the verification of the connections between established stations, and the extension of the worldwide gravity net including ocean areas. In remote territories like Antarctica, gravity measurements were also made in conjunction with seismic and glacial studies to improve our knowledge of isostatic compensation in that area.

DoD was also one of the pioneers that recognized the importance of a "combined" solution from surface gravity information and observations of satellite orbit perturbations available from the IGY earth satellite programs. From the initial computation of the third zonal harmonics in early 1959, DoD was among the first to solve a global geopotential model under the World Geodetic System project the following year.

In its logistics support role, the U.S. Navy's ship *The Compass Island* provided a gyro-stabilized platform for the first successful sea surface gravity observations on November 20, 1957. This historic operation thus established that it would be possible to acquire data from over 80% of the earth's surface in the succeeding years. Along similar lines, indispensable airborne and ground support were supplied to the IGY Antarctica gravity traverse teams by a U.S. Navy task force.

6. Geodetic Laser System

The pioneering efforts to develop satellite laser illuminating and ranging techniques were successfully conducted by AFGL in 1965. Also, experiments with corner-cube reflectors (CCR) by the Army Map Service (now DMA) began in the years following the IGY. These are examples of DoD's indirect contribution to geodesy. It is interesting to note that earlier attempts with CCR's were performed with 60-inch searchlight beams. On the basis of the knowledge acquired as a result of the IGY, it is not a surprise that these attempts failed because of large amounts of backscatter.

As the system design progressed, the CCR's were replaced by more efficient retroreflectors. The original concept to measure distances with geodetic accuracy became a reality. We all know that in today's world lasers form the essential ingredient of some of the most accurate and complex geodetic instruments, and the word laser itself has become synonymous with high accuracy geodesy.

7. Summary

On this occasion marking the 25th anniversary of the IGY, this article has recalled some of the DoD activities of the initial years that significantly contributed to the IGY satellite programs involving active, passive, and cooperative satellites.

Today, DoD continues to support the development, enhancement, and application of new technology in such areas as satellite altimetry, airborne gravimetry, gravity gradiometry, inertial surveying, interferometry, charge coupled devices for geodetic astronomy, and others. And, of course, there is a tremendous effort going into the Global Positioning System, which is scheduled to be operational later in this decade.

Time does not allow mention of all the contributions made by DoD components that fulfilled the IGY objectives in satellite geodesy theory, practical methodology of data reduction, satellite tracking techniques and instrumentation, gravimetric investigations, and other basic research. It suffices to say that much of today's technology is a result of the stimulus provided by the dedicated and concentrated efforts begun during the IGY. It has been a fantastic 25 year era for geodesy and for us.

Contributions require people, and while it is not our intent to mention all of those associated with or supported by DoD during this era, the geodetic world will remain beholden to those represented by the likes of the following: the O'Keefes, Kaulas, Chovitzes, Fischers, Leroys, Auderles, Kerstners, Wolfenbachs, Newtons, Cohens, Whipples, Hedens, Markowitzes, Winklers, Heiskanens, Uotilas, Muellers, Rapps, Woollards, Tatwanis, Williamses, Murrays, Edwards, Rapigeorges, Wittaners, Fallers, Benders, Thompsons, Szabos, Schmids, Mancinis, Gambinos, Martins, Deckers, Ballews, Daughertys, Wilcoxes, Ewings, Whites, Macombers, Schwiderskis.

Acknowledgments. Our appreciation is provided to Muneendra Kumar of the Defense Mapping Agency Hydrographic/Topographic Center, who assisted us with this article.

News

Antarctic Research Priorities Set

Highest priority for future research under the U.S. Antarctic Program should be given to the "extraction of the unique climatic record preserved in the Antarctic ice sheet" and to "the study of the response of marine life to the unique environment at the edge of sea ice." That's the word from the National Research Council's (NRC) Polar Research Board, which was asked by the National Science Foundation (NSF) to recommend priorities for research efforts in the Antarctic. NSF funds the U.S. Antarctic Program. The board ranked eight large-scale research projects in order of priority, identified three smaller, more specific projects that should be included in the U.S. Antarctic Program, and listed other necessary, supportive activities with "widespread implications and applications."

The board says that the best long-term results will be gleaned from the U.S. Antarctic Program with a mixture of the "intensive, integrated, large-scale projects focused on one or more of the principal research questions," the "smaller-scale, lower-cost projects," and "other activities, including ongoing collection and analysis of data, publication of scientific results, and production of maps."

In addition to the two projects tagged as highest priority, the Polar Research Board recommended in its report, *Research Emphases for the U.S. Antarctic Program*, six other large-scale, integrated projects. Very high priority, in the board's view, should go to

- A major interdisciplinary study of the continental margin in the Ross Sea area of Antarctica, involving marine geology and geophysics, oceanography, and marine biology.
- A program of auroral, magnetic, ionospheric, and thermospheric measurements from South Pole Station to develop an understanding of global energy transfer in the magnetospheric cusp and polar cusp.
- An interdisciplinary investigation of the structure and intensity of the Weddell gyre and the impact of the associated fluxes on the climatic, glacial, and biological environment.

High priority was assigned to

- A coordinated program of geophysical studies aimed at understanding West Antarctic crustal structure and history and the dynamics of the ice sheet.
- A multidisciplinary study integrating physical and biological measures to determine the causes for, and ecological consequences of, the swarming behavior of krill.
- A study of the interaction between electromagnetic waves and energetic particles, making use of conjugate-point measurements.

In addition to those eight projects, the board recommended three small projects. The first, designated as very high priority, is studying the life-history patterns and adaptations of the Antarctic biota. The remaining two, assigned high priority, are measuring the heat budget at and around South Pole Station and studying the biogeochemical processes in Antarctic ecosystems.

Other activities within the purview of the U.S. Antarctic Program that the Polar Research Board said should be continued include "the production of topographic and geologic maps; the collection of meteorites; and the monitoring programs at South Pole and McMurdo stations that provide data on upper atmospheric, cosmic, and solar phenomena, earthquakes, and earth tides, constituents of the atmosphere, and standard meteorological data."

To effectively implement the research projects identified, the NRC board said that "support systems permitting longer operating seasons and covering wider geographic areas" are required.

Charles R. Bentley, at the University of Wisconsin's Geophysical and Polar Research Center, is chairman of the Polar Research Board. Three ex officio members and four agency liaison representatives complement the 16 scientists who constitute the board. W. Timothy Hushen is executive secretary.

—BTR

Diamonds at High Pressure

New calculations indicate that diamonds may not have any phase changes at pressures below 23 × 10^{11} N m^{-2} (23 Mbar) (M. T. Yin and M. I. Cohen, *Physical Review Letters, 50*, 2006, 1983). The importance of this result of course affects the applications of diamonds beyond their value as gem stones. Single crystal diamonds have served as very strong windows for the transmission of a range of radiation spectra in high-pressure experiments. The ultimate strength of diamonds, however, could mark the limit of experiments at 1 Mbar and higher pressures.

A few laboratories have been able to experiment at pressures equivalent to those at the earth's mantle-core boundary (approximately 1.5 Mbar), but such experiments can hardly be considered routine. Extrapolations from experiments done by the General Electric Research Laboratory in Schenectady, N.Y., and by J. A. Van Vachten (*Physica Status Solidi B, 47*, 261, 1971) suggested that diamonds might undergo a phase change at about 1.3 Mbar; if so, diamonds used as window-anvils would fail at the transition. There has been speculation that the phase change would include a reorder of diamond's electronic structure to the metallic state.

Yin and Cohen calculated that a high-pressure transition to the simple cubic structure would occur in diamonds at 23 Mbar. The pseudopotential technique they employed has proven successful in numerous other cases and is becoming a valuable tool in crystal calculations. According to an account by J. Willis of the Clarendon Laboratory, University of Oxford, "Yin and Cohen assumed only the atomic number of the element and the type of crystal structure and then determined the lattice constants, cohesive energies and bulk moduli" (*Nature, 305*, 102, 1983).

The earlier work of Van Vechten had pointed toward a β-tin (tetragonal) crystal structure for the high-pressure carbon phase, in analogy with silicon and germanium. Yin and Cohen obtained consistent results but a different result for the diamond. The 23 Mbar transition pressure bodes well for making experiments above the present 1.5–2 Mbar maximum. The new results say nothing, however, of the yield strength of diamond, which could result in flow or failure at considerably lower pressures.—*PMB*

Real-Time Ionosphere Data

Ionospheric electric fields estimated from observations with the STARE (Scandinavian Twin Auroral Radar Experiment) system have been available in real time since August 1983. Such field information is very valuable: To carry out well-defined experiments in the earth's ionosphere/magnetosphere system, it is desirable to have access in real time to data which define the state of this system. On the principle that no geophysical event is unique, conditions in the ionosphere/magnetosphere are recurrent, and thus the state wanted by an experimenter will reoccur eventually; to determine when, experimenters have usually relied on observations that yield information on currents (magnetometers) and charged particle precipitation (riometer, visual auroral data).

STARE consists of two coherent radars with a common field of view covering 200,000 km² of the *E* region over northern Scandinavia. Simultaneous observations of backscatter intensities and Doppler velocities from the two radars allow estimates of the ionospheric electric field with a spatial resolution of 20 × 20 km and a temporal resolution of typically 20 s. The only requirement is that the electric fields exceed a threshold of about 15 mV m^{-1} for generation of radar auroral irregularities (see E. Nielsen and J. D. Whitehead, *Advances in Space Research, 2*, 131, 1983, and R. A. Greenwald et al., *Radio Science, 13*, 1021, 1978).

The radar stations are computer controlled (Data General Nova 2, 16 kilobyte memory) and in continuous operation. Both stations are now equipped with communication software (written by C. Steward, Leicester University, UK) and hardware, which permit them to be reached over the normal telephone system. All parameters governing the radar operations as well as all measurements are transmitted at the end of each integration time. This transmission does not interfere with the normal operation of the radar.

All experimenters desiring access in real time to STARE data are invited to call one or both of the radar stations and to use the transmitted data to help determine when an experiment should be initiated. Should the STARE system be used later in the analysis and interpretation of observations, then a cooperation with the STARE group should be arranged. We believe that this access could be of interest for ground-based experiments, satellite experiments (for example, HEATING, EISCAT, VIKING), and rocket and balloon experiments. Two rocket ranges (ANDOYA and ESRANGE) lie within the STARE field of view.

For more information, contact E. Nielsen, Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, FRG. The STARE system is operated by the Max-Planck-Institut für Aeronomie in cooperation with ELAB, University of Trondheim, Norway, and the Finnish Meteorological Institute, Helsinki, Finland.

Prospecting With Neutrinos

One of the latest attempts to explore the interface between physics and geophysics is the extravagant scheme of Alvaro De Rújula, Sheldon Glashow, Robert Wilson, and Georges Charpak, to be published in *Physics Reports*. In what these theoretical and experimental physicists described recently as "our mad project" (*Physics Today*, August 1983), a high-energy neutrino beam is to be used as a geophysical prospecting tool.

The beam would be able to look for oil, natural gas, and high-atomic-number metal ores, and it would be able to profile the vertical density distribution of the earth. De Rújula et al. come to this project from the world of big physics machines, so it is natural to expect that the "Geotron," the field instrument to supply and focus the neutrino beam, is to be big also.

To their credit, the four particle physicists have worried about the consequences and the costs. They think that the machine could be built for about $1 billion, or even less; however, they concede their real concern is that it would be even more: "it might cost very much more if built under the loving supervision of present-day bureaucrats. The construction could well be drawn out into a jobs-for-all Nirvana for years as the costs double and then double again. This sobering pitfall for projects is not, experience informs us, the exception."

What the neutrino beam really does is to provide a train of acoustical disturbances and nuclear particles along its path as it travels through the earth. The process functions as follows: "When a nucleus hits a nucleus it produces a forward moving shower of charged particles (which ionize the medium) and neutral particles; the neutrals (mainly pions) decay to produce additional ionizing radiation. This sudden deposition of energy, produced in a narrow cone of ionization, produces an acoustical signal."

The neutrinos, whose energies are measured in TeV, are produced by a Geotron, which is an underwater-based synchrotron. The Geotron would provide a proton beam of 10–20 TeV that in turn would impinge upon a target to yield a collimated beam of pions and kaons that would undergo decay as mesons to neutrinos. This process of conversion would be tightly collimated in a tunnel called a Snout. The Snout is actually a flexible tube that holds a series of superconducting magnets. Even at a distance of 1000 km the low divergence of the neutrino beam would result in a radius of only 10 m.

GENIUS (Geological Exploration by Neutrino-Induced Sound), is the application of the Geotron to locate petroleum deposits at great distances. At 1000 km an array of geophones with frequency ranges of 1–100 Hz would be tuned in on the acoustical beam and at the same time filter background and seismic noise. Enormous areas can be surveyed and at great depth (the signal energy falls off with the first rather than the fourth power of depth, as with seismic waves).

It also would be feasible, according to the proposed plan, to measure the muon beam. Thus GENIUS would become GEMINI (Geological Exploration with Muons Induced by Neutrino Interaction). Muon sensors could detect differences as the beam passed through high-atomic-number metal concentrations.

A crucial property of the beam in all applications is that it can penetrate the entire earth. In the Geoscan mode a special, vertically oriented beam of neutrinos would be aimed at the earth in such a way that it would travel through the center of the earth, penetrating the core. Muon detectors would sample the beam at various angles. It should be possible to obtain a determination of the earth's radial density distribution to high accuracy in a short time.

The project is being proposed as a selling point for construction of the Texatron, the huge hadron collider accelerator that has been suggested for the Texas A&M campus. The Texatron could provide a neutrino beam that would be used to test these ideas of geophysical exploration.—*PMB*

China's Petroleum Reserves

Perhaps because of declining yields inland, the People's Republic of China has moved to its storm-ridden coast to develop additional petroleum reserves. During 1979 and 1980, 44 foreign oil-exploration companies engaged in what has been termed the world's record "seismic shoot" over 411,000 km² extending from the Yellow Sea through the South China Sea, and including Beibu Wan (Gulf of Tonkin), the bay lying east of Hanoi and west of Hainan Island. These offshore oil reserves are estimated to be 40–100 billion barrels.

The seas off the mainland are relatively shallow (most drilling has been done in less than 100 m) but they are stormy. According to a recent description, "Typhoons can . . . occur in the area at almost any time of the year, and the strong winds (160 km h^{-1} or more) which they generate frequently wreak havoc in the Philippines, Vietnam, China, and occasionally, Hong Kong. Typhoon Vera, which hit southern China in late July, did immense damage and claimed dozens of lives. The main implications for oil operation naturally relate to rig design and safety measures but onshore facilities will also have to be designed accordingly" (*New Scientist*, Sept. 8, 1983).

Exploration and drilling techniques similar to those used in the North Sea, although to shallower depths, are being used. The political boundaries will not be so easily settled, however. The China Sea and its islands are a great potential source of political conflict, the entire area being claimed by mainland China, the Philippines, Taiwan, Vietnam, and others.—*PMB*

Society Merger Rejected

Members of the American Society of Photogrammetry (ASP) and members of the American Congress on Surveying and Mapping (ACSM) have rejected a plan to consolidate the two societies.

An affirmative vote of at least two-thirds of each society's members present or represented by proxy was required for the merger. Voting in favor of the consolidation plan were 61.2% of ASP voters and 63.7% of ACSM voters. Almost 50% of eligible members of each society participated in the September 21 vote.

The consolidation had been discussed for several years and was formally proposed in June 1981. In September 1981 the two societies agreed to affiliate (*Eos*, November 10, 1981, p. 765) and agreed to prepare a consolidation plan. Although the consolidation was rejected last month, the societies will retain their affiliation. As affiliated societies, they are located in the same building in Falls Church, Va., and share a single governmental affairs program and an educational program.

JOI Seeks Nominations

Joint Oceanographic Institutions (JOI), Inc., is seeking nominations for a new panel to coordinate scientific ocean drilling. To be called the U.S. Science Advisory Committee (USSAC), the panel would complement the work of the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES).

The Board of Governors of JOI says it wants USSAC to include broad representation from academic, government, and industry sectors outside the 10 JOI member institutions, and it is inviting nominations, including a brief vita and list of publications, for membership on USSAC to be sent, by November 3, to John H. Chowarthy, JOI, Inc., 2100 Pennsylvania Ave., N.W., Suite 316, Washington, DC 20037.

Geophysicists

Richard C. Hart is the new secretary of the U.S. National Committee for the Committee on Space Research (COSPAR). Hart succeeds *Dean Kastel*, who is now the executive secretary of the National Research Council's Space Science Board. In addition to his new duty with COSPAR, Hart serves as the staff officer for the Space Science Board committees on space astronomy and astrophysics, solar and space physics, and data management and computation.

John H. McElroy was recently appointed assistant administrator for the National Environmental Satellite, Data, and Information Services of the National Oceanic and Atmospheric Administration. McElroy had been acting assistant administrator since February 1982.

Timothy D. Steele has accepted a position as water resources manager of the Denver office of In-Situ, Inc., a high-technology consulting company serving the mining and energy industries. Steele previously worked for more than 13 years with the U.S. Geological Survey's water resources division. Most recently, he was chief of the water quality group in the Denver office of Woodward-Clyde Consultants.

Nominations for Medals and Awards

William Bowie Medal. Awarded for outstanding contributions to fundamental geophysics and for unselfish cooperation in research.

Maurice Ewing Medal. Honors an individual who has led the way in understanding the physical, geophysical, and geological processes in the ocean; who is a leader in ocean engineering, technology, and instrumentation; or who has given lasting distinguished service to the marine sciences.

Robert E. Horton Medal. Given for outstanding contributions to the geophysical aspects of hydrology.

James B. Macelwane Awards. Up to three awards are given each year for significant contributions to the geophysical sciences by a young scientist of outstanding ability. Recipients must be less than 36 years old.

Letters of nomination outlining significant contributions and curriculum vitae should be sent directly to the appropriate committee chairmen: *Bowie Medal* - Eugene M. Shoemaker, U.S. Geological Survey, 2255 Gemini Drive, Flagstaff, AZ 86001; *Ewing Medal* - Robert O. Reid, Department of Oceanography, Texas A&M University, College Station, TX 77843; *Horton Medal* - R. Allan Freeze, Department of Geological Sciences, University of British Columbia, Vancouver, B.C., Canada V6T 1W5; *Macelwane Award* - J. Freeman Gilbert, IGPP A-025, University of California/San Diego, La Jolla, CA 92093.

Deadline for Nominations is November 1, 1983.

Recent Ph.D.'s

Eos periodically lists information on recently accepted doctoral dissertations in the disciplines of geophysics. Faculty members are invited to submit the following information, on institution letterhead, above the signature of the faculty advisor or department chairman: the dissertation title, author's name, name of the degree-granting department and institution, and month and year degree was awarded. If possible include the current address and telephone number of the degree recipient (this information will not be published).

Methane and Radioactive Isotopes in Submarine Hydrothermal Systems, Kyung-Ryul Kim, Scripps Institution of Oceanography, Univ. of California, San Diego, June 1983.

The Oceanographic and Geoidal Components of Sea Surface Topography, Victor Zlotnicki, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, June 1983.

Vorticity and Upwelling Near an Isolated Feature on the Continental Shelf, Stephen M. Chiswell, Marine Sciences Research Center, State Univ. of New York, Stony Brook, August 1983.

Effects of Size, Age and Photoperiod on Hypoosmoregulation in Brook Trout Salvelinus Fontinalis, Stephen D. McCormick, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Foraminiferal Trace Elements: Uptake, Diagenesis, and 100 m.y. Paleochemical History, Margaret L. Delaney, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Processing and Inversion of Arctic Ocean Refraction Data, Gregory L. Duckworth, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Purification and Characterization of the Hepatic Microsomal Monooxygenase System from the Coastal Marine Fish Stenotomus Chrysops, Alan V. Klotz, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Wave-Induced Turbulent Flow Near a Rough Bed: Implications of the Time-Varying Eddy Viscosity, John H. Trowbridge, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, September 1983.

Effects of Pore Pressure, Confining Pressure and Partial Saturation on Permeability of Sandstones, Joel Dan Walls, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., January 1983.

Relative Motions Between Oceanic and Continental Plates in the Pacific Basin, David Cal Engebretson, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., January 1983.

Velocity, Attenuation, and Natural Fractures in Shallow Boreholes, Daniel B. Moos, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., January 1983.

A Study of the Seismic Structure of Upper Oceanic Crust Using Wide-Angle Reflections, Kristin M. M. Rohr, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, February 1983.

Spectral Reflectance of Near-Earth Asteroids: Implications for Composition, Origin and Evolution, Lucy A. McFadden, Dept. of Geology and Geophysics, Hawaii Institute of Geophysics, Univ. of Hawaii, May 1983.

Dip-Moveout by Fourier Transform, Ira David Hale, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., June 1983.

Flow and Skin Friction over Natural Rough Beds, Christopher Paola, Joint Program in Oceanography and Oceanographic Engineering, WHOI/MIT, June 1983.

Migration of Reflection Seismic Data in Angle-Midpoint Coordinates, Richard Albert Quolini, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., June 1983.

New Techniques in the Analysis of Geophysical Data Modelled as a Multichannel Autoregressive Random Process, P. A. Tyraskis, Laboratory in Applied Geophysics, Dept. of Mining and Metallurgical Engineering, McGill Univ., Montreal, Canada, June 1983.

Spatial Coherency of Seismic Waveforms, Keith McLaughlin, Dept. of Geology and Geophysics, Univ. of California, Berkeley, June 1983.

Wave Propagation in Porous Rock and Models for Crustal Structure, Terry Dean Jones, Dept. of Geophysics, School of Earth Sciences, Stanford Univ., June 1983.

Books

An Introduction to Crystal Optics

P. Gay, Longman, New York, ix + 262 pp., 1982, $14.95.

Reviewed by Donald E. Sands

An Introduction to Crystal Optics is a reprinting in paperback of a book first published in 1966. The preface states that the only modification made in this version is an updating of the bibliography; however, a comprehensively revised edition is promised "before long."

The book is essentially a treatment of classical optical crystallography, little touched by twentieth century science. The tone is descriptive and qualitative, equations are rare, and the physics tends to be superficial. If physics is not its forte, descriptive clarity is. This little volume is recommended for its well-written exposition of the study of crystals with the aid of the polarizing microscope. It will serve as an excellent introduction to microscopy or optical mineralogy. It will also be useful to the advanced reader seeking elementary explanations of what other works treat in a more erudite manner.

The first five chapters discuss the properties of light and its transmisison through crystals. The wave character of light is described by analogy to water waves. The Huygens' construction is applied to the analysis of wave motion through isotropic media. After introducing optical anisotropy via the transmission of light through calcite, the Huygens' construction is extended to uniaxial crystals. The indicatrix is presented as an aid to understanding the transmission of light through crystals of any symmetry. Absorption in anisotropic media, dispersion, and pleochroism are covered in a brief chapter.

These presentations of the properties of light are followed by six chapters of a practical nature, treating the production of polarized light, the polarizing microscope, microscopic methods of measuring isotropic refractive indices, interference effects in parallel light and in convergent light, and dispersion of the indicatrix. The final, and longest, chapter shows how to apply the principles of the preceding chapters to microscopic observations. Relegated to appendices are the geometric properties of the indicatrix, the analysis and superposition of waves, the minimum deviation and the critical angle methods of measuring refractive indices, and optical activity.

Exercises accompany most chapters. A few of these are simple numerical problems, for which answers are supplied at the end of the book, but many are laboratory exercises requiring the use of a polarizing microscope.

Donald E. Sands is with the University of Kentucky, Lexington, KY 40506-0032.

Mount St. Helens Eruptions of 1980: Atmospheric Effects and Potential Impact

NASA SP-458, R. E. Newell and A. Deepak (Eds.), NASA Scientific Information Branch, Washington, D. C., 119 pp., 1982.

Reviewed by R. Reiter

This clearly and uniformly arranged little book reports the results of a NASA workshop held November 20–21, 1980, in Washington, D. C., on the atmospheric effects of the 1980 Mount St. Helens eruptions.

It is divided into the following six chapters: (1) Volcanological Description of the May 18, 1980, Eruption of Mount St. Helens, (2) Transport and Dispersion, (3) Chemical and Physical Measurements of the Volcanic Cloud Made In Situ, (4) Remote Sensing of Mount St. Helens Effluent, (5) Chemistry of the Mount St. Helens Effluent, and (6) Influence of Mount St. Helens and other Volcanoes on Climate and Weather. Each chapter closes with conclusions and references.

The single chapters give a brief and clear description of the knowledge of the volcanic eruption itself; the resultant loading of the stratosphere with ejecta; the to-be-expected chemical processes in the stratosphere caused by the eruptive material; the eruptive material's time behavior; and the transport and diffusion processes.

In addition, the book gives a detailed description of remote sensing of Mount St. Helens effluent, including satellite-based measurements (SAGE, SAM II), lidar systems, and methods of radiation measurements. Lidar results from stations in Europe and Japan are used in graphs, unfortunately without references.

A special chapter is devoted to the potential impact on weather and climate of the Mount St. Helens eruption (the strongest eruption since Fuego in 1974). A possible stratospheric warming and cooling of the earth's surface is tentatively suggested. Most prominent in the recommendations of this chapter is the need for long-term measurements of the stratospheric background in order to acquire precise knowledge of the undisturbed conditions prior to future eruptions. Such eruptions were not long in coming: Alaid in 1981 and, in 1982, the massive eruption of El Chichón, whose terrestrial impacts can certainly no longer be neglected.

Mount St. Helens' eruption was thus an impressive reason for many researchers to prepare themselves for the eruptions of the recent past: That is the sense in which this book must be regarded as very useful, although, considering the totally changed atmospheric conditions due to El Chichón's eruption, no longer quite up to date. The book's text and illustrations (30 of them, many in color) are well printed and it should be available in the libraries of all engaged or interested in research on the global atmospheric process.

Yet, at the end, a remark: Right before the workshop on the topics of the book under review, another NASA symposium was held November 18–19, 1980, also in Washington, D. C. The title was almost the same and the scientists in attendance were 3 times more numerous; the papers are printed in their entirety as NASA Conference Publication 2240. The volume has 303 pages, approximately 180 figures, and very complete references. It is only in part identical with the book under review and it, too, deserves special attention.

R. Reiter is with the Fraunhofer-Institute for Atmospheric Environmental Research, D-8100 Garmisch-Partenkirchen, Federal Republic of Germany.

New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Statistics on Spheres, G. S. Watson, John Wiley, New York, x + 238 pp., 1983, $21.50.

Stellar and Planetary Magnetism, vol. 1, *The Fluid Mechanics of Astrophysics and Geophysics*, A. M. Soward (Ed.), Gordon and Breach, New York, xi + 375 pp., 1983, $69.50.

To Quench Our Thirst: The Present and Future Status of Freshwater Resources of the United States, D. A. Francko and R. C. Wetzel, Univ. of Michigan Press, Ann Arbor, viii + 148 pp., 1983, $8.50.

Underground Sound: Application of Seismic Waves, J. E. White, Elsevier, New York, xvi + 254 pp., 1983, $59.50.

Variations in the Global Water Budget, Symposium on Variations in the Global Water Budget, Oxford, 1981, A. Street-Perrott, M. Beran, and R. Ratcliffe (Eds.), D. Reidel, Boston, xiv + 518 pp., 1983.

World Ocean Atlas: Arctic Ocean, Introduction and Index, Pergamon, New York, xx + 41 pp., 1983.

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POSITIONS AVAILABLE

North Carolina State University/Marine Chemist. The Department of Marine, Earth, and Atmospheric Sciences invites applications for a 9 month, tenure track position at the assistant or associate professor level. The candidate must have a Ph.D. and will be expected to interact with various research programs within the department such as: radiochemistry, stable isotope and trace metal geochemistry, sedimentology, ocean circulation, air-sea interaction, and biological oceanography. Responsibilities include conducting a viable research program as well as teaching and advising graduate students. Applicants should forward a resume and the names of at least three references to: Dr. David J. DeMaster, Chairman, Search Committee, P.O. Box 5068, North Carolina State University, Raleigh, NC 27650. Application material should be sent by November 30, 1983.

North Carolina State University is an equal opportunity/affirmative action employer.

Florida International University/Faculty Position in Geology. The Geology program at Florida International University is expanding and plans to increase its faculty in the next few years. In order to complement existing instructional and research strength, the University invites applications for tenure track positions at the Assistant Professor level in the following areas of specialization:

1. Igneous Petrology/Geochemistry/Economic Geology
2. Geophysics/Marine Geology
3. Stratigraphy/Sedimentology

Successful applicants must have demonstrated an ability for high quality teaching and the potential to establish a productive research program in the area of speciality. Subject to final approval of funding, appointments will begin in August 1984. Deadline application is February 2, 1984. Send a resume, brief description of teaching experience and research interest, transcripts, and three letters of reference to:

Dr. L. Keller, Chairman
Department of Physical Sciences
Florida International University
Tamiami Trail
Miami, FL 33199

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National Center for Atmospheric Research/Visitor Applicants. At the High Altitude Observatory, Visitor Appointments are available for new and established Ph.D.'s for up to one year periods to carry out research in solar physics, solar-terrestrial physics, and related subjects. Applicants should provide a curriculum vitae including education, work experience, publications, the names of three scientists familiar with their work, and a statement of their research plans. Applications must be received by January 15, 1984, and they should be sent to: HAO Visitor Committee, High Altitude Observatory, National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307.

NCAR is an Equal Opportunity/Affirmative Action Employer.

Assistant or Associate Professor/The Chesapeake Biological Laboratory (CBL) of UMCEES. Applications invited for a tenure-track faculty position in marine or estuarine chemistry or geochemistry. The successful candidate will develop a program of research in their own field of interest; will play an important role in a growing program of chemistry and geochemistry at CBL, and will participate in interdisciplinary research programs with other scientists with specialties in chemistry, sedimentology, and physical and biological oceanography. Some preference will be given to candidates with interests in trace or major element geochemistry or organic geochemistry, particularly in relation to sediments. However, all candidates with interests in the broad subject areas are encouraged to apply.

Applicants should have a strong post-doctoral research record, demonstrated interests in interdisciplinary research, and an interest in teaching and graduate research. Curriculum vitae, description of research interests and a list of three to five references should be sent to: Dr. Jay C. Means, Chairman—Search Committee, UMCEES, Chesapeake Biological Laboratory, Box 38, Solomons, Maryland 20688–0038. Applications received by October 31, 1983 will be assured full consideration.

The University of Maryland is an Affirmative Action/Equal Opportunity Employer.

Atmospheric Dynamics and Planetary Physics/The Johns Hopkins University. The Department of Earth and Planetary Sciences intends to make a tenure-track faculty appointment in each of these areas, one in July 1984 and the other in July 1985. The Atmospheric Dynamics post will be at the Assistant Professor level; applicants should have a demonstrated capacity for innovative research with, preferably, post-doctoral experience. The appointment in Planetary Physics will be made at a level commensurate with the attainments of the successful candidate; for appointment as full professor, a high international reputation for research accomplishments is expected. Women and minority candidates are especially encouraged to apply.

It is expected that the appointees will develop programs in teaching and research that will complement the activities of the present groups in geophysical fluid dynamics and geophysics, whose research interests include turbulence, waves, air-sea interactions, stratified flow dynamics, convection, mesoscale meteorology, dynamics of the earth's interior, and volcanology. The appointee in planetary physics will be encouraged to interact strongly with scientists at the Space Telescope Science Institute, which is on campus. The University is a member of the University Corporation for Atmospheric Research.

Applications should include a curriculum vitae, copies of one or two recent publications and the names of at least three referees. They should be sent by January 15, 1984 to Professor O.M. Phillips, Chairman, Search Committee, Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, Maryland 21218.

The Johns Hopkins University is an Equal Opportunity Employer.

Meteorologist/The City College of The City University of New York. The Department of Earth and Planetary Sciences invites applications for an anticipated opening in meteorology. The appointment will start September, 1984. Applicants should have completed the Ph.D. by the time of appointment and have a strong background in synoptic meteorology and computer applications. In addition, the individual should have an interest in atmospheric chemistry or pollution as applied to urban areas, or physical oceanography. The person hired will be required to teach courses in meteorology, and possibly physical oceanography as well as develop and maintain an active research program. Participation in the C.U.N.Y. Ph.D. Program in Earth and Environmental Sciences is anticipated. Rank and salary will be commensurate with experience. Send resume, transcripts and three letters of reference by November 30, 1983 to Professor Dennis Weiss, Chairman, Department of Earth and Planetary Sciences, the City College, 138 Street and Convent Avenue, New York, N.Y. 10031.

The City College of the City University of New York is an equal opportunity affirmative action employer.

Research Associate Position in Cratering Mechanics/University of Arizona. A position is open for a young scientist interested in applying physical principles to the mechanics of impact cratering and studying the origin of meteorites, the morphology of large craters or the climatic effects of a large terrestrial impact. The applicant should have a Ph.D. in geophysics or a related field. Experience with large numerical codes is desirable. A resume and three letters of reference should be sent to: H. J. Melosh, Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721. All applications must be received by Nov. 1, 1983.

The University of Arizona is an equal opportunity employer.

Louisiana State University/Chas. T. McCord, Jr. Endowed Professorship in Hydrocarbon Exploration: The Geology Department is seeking an internationally recognized leader in some research specialty critical to the search for oil and gas to fill the Chas. T. McCord, Jr. Endowed Professorship. Applicants are expected to maintain scholarly research in their area of specialty. Rank at Full Professor level with salary competitive with endowed professorships at other major research universities. For consideration send resume, three letters of reference, and a description of future research programs to Lyle McGinnis, Faculty Search, Department of Geology, Louisiana State University, Baton Rouge, LA 70803–4101. Search will remain open until position is filled.

LOUISIANA STATE UNIVERSITY IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY EMPLOYER.

Washington University, St. Louis. Washington University, St. Louis, announces tenure track positions for the fall of 1984. Preference is for candidates in Geophysics, Structural Geology, Metamorphic Petrology, or Petrology of Extraterrestrial Materials.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references to Larry A. Haskin, Chairman, Department of Earth and Planetary Sciences, Washington University, St. Louis, Missouri 63130. Applications received through January 1, 1984.

Washington University is an equal opportunity/affirmative action employer.

North Dakota State Water Commission/Geohydrologist. To work in aquifer evaluation and management. Bachelor's degree with two years experience or masters degree with experience in quantitative techniques required. Background in watershed modeling, soil physics or unsaturated flow processes desired. Salary range $1555-$2278 per month. Send resume to:

North Dakota State Water Commission
Hydrology Division
900 East Boulevard
Bismarck, North Dakota 58505

North Dakota State Water Commission is an equal opportunity/affirmative action employer.

The University of New Mexico/Research Associate. Applications are invited for a permanent position as a research associate in the Department of Geology at The University of New Mexico. The applicant should have experience in characterizing the structure, morphology and chemistry of solid materials with the analytical electron microscope (to be purchased this year) and will be responsible for the day-to-day operation of the instrument. The work will involve the characterization of metallic, ceramic and composite materials, including rock-forming minerals. The scanning transmission electron microscope will be part of an Electron Microbeam Analysis Facility which includes a fully-automated ARL EMX-SM electron microprobe; an automated, five spectrometer, 733 JEOL Superprobe and an Hitachi 450 scanning electron microscope. Each instrument has an EDS and is housed in newly constructed laboratories. Experience in x-ray diffraction crystallography and secondary x-ray fluorescence anlaysis would be useful.

The successful applicant is expected to maintain his/her own active research program and to interact with faculty throughout the University in cooperative materials science research.

A Ph.D. is required and the salary is in the range of $27,000 to $35,000/12 months commensurate with experience. Applicants should forward a detailed resume to R. C. Ewing, Department of Geology, University of New Mexico, Albuquerque, New Mexico 87131. Deadline for applications is December 15, 1983.

The University of New Mexico is an Equal Opportunity Employer.

University of Florida. The Department of Geology invites applications for a tenure-track position beginning with the fall term, 1984. The position will be filled at the assistant or associate professor level. A Ph.D. is required and salary will be commensurate with qualifications. Although any research specialty will be considered, preference will be given to those with interest in these general areas: geochronology-isotope geology or low-temperature geochemistry-chemical sedimentology. Send curriculum vitae and 3 letters of reference by January 15, 1984 to: Dr. N.D. Opdyke; Department of Geology; 1112 GPA; University of Florida; Gainesville, Florida 32611.

The University of Florida is an equal opportunity/affirmative action employer.

Faculty Position in Geology/University of Puget Sound. Tenure-track Assistant Professor. Field-oriented Geomorphologist with strong interest in Quaternary glacial stratigraphy and landscape processes; to begin February 1, 1984 or September 1, 1984; salary commensurate with experience. The department (3 career faculty) has long established, successful undergraduate program with joint faculty/student research. Team teach Physical Geology—Topics (all three faculty teach both lecture and labs), and teach a senior level Geomorphology course (lecture and lab) with a process and quantitative focus, including computer applications (Fall). Teach Physical Geology (lecture and lab) and share teaching responsibilities in Historical Geology (Spring). Participate in departmental/University governance, advise students, and continue professional development. Ph.D. in Geology, ability to teach both majors and non-majors, and ability to carry out cooperative, interdisciplinary research with undergradaute geology and other science majors. (Additional info available at Indianapolis GSA meetings). Submit detailed vita, statement of short- and long-term career objectives, transcripts, and names of three references by November 10, 1983, to: Geology Search, University of Puget Sound, P.O. Box 7297, Tacoma, WA 98407.

An Equal Opportunity, Affirmative Action Educator/Employer.

Postdoctoral Position. Available for the experimental study of the entrainment, deposition, and transport of sediments in lakes and oceans. The research will be primarily in the laboratory but will also involve some field work. Competence in experimental fluid mechanics and interest in environmental problems is necessary. The position will remain open until filled. Applicants should send resume and names of three references to:

Professor Wilbert Lick
Department of Mechanical & Environmental Engineering
University of California
Santa Barbara, CA 93106

An Equal Opportunity/Affirmative Action Employer.

Postdoctoral Awards in Ocean Science and Engineering. Woods Hole Oceanographic Institution invites applications for 1-year postdoctoral scholar awards from new and recent doctorates in fields of biology, chemistry, engineering, geology, geophysics, mathematics, meteorology, and physics, as well as oceanography. Recipients of awards are selected on a competitive basis, with primary emphasis placed on research promise.

Fellowship stipend is $22,600. Appointees are eligible for group health insurance and a modest research budget. Recipients are encouraged to pursue their own research interests independently or in association with resident staff. Completed applications must be received by January 1, 1984 for 1984–85 awards. Awards will be announced by March 1st. Write for application forms to: *Dean of Graduate Studies, P.O. Box E, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts 02543.*

Equal Opportunity/Affirmative Action Institution.

Ohio State University/Seismologist-Tectonophysicist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a geophysicist with research interests in seismology and/or tectonophysics. The successful applicant must be prepared to assist in teaching exploration geophysics courses, advanced topics in his/her speciality, conduct research, and supervise graduate students. Preference will be given to candidates with post-doctoral or industrial experience. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-1349 or 422-2721

Applications should include a resume, a statement of research interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

The Ohio State University is an equal opportunity/affirmative action employer.

Earth Sciences

The Lamont-Doherty Geological Observatory of Columbia University invites scientists interested in any field of the earth sciences to apply for the following fellowships: Two postdoctoral fellowships, each awarded for a period of one year (extendable to two years in special instances) beginning in September, 1984 with a stipend of $25,000 per annum.

Completed applications are to be returned by January 15, 1984. Application forms may be obtained by writing to the **Director, Lamont-Doherty Geological Observatory, Palisades, New York 10964.** Award announcements will be made February 28, 1984, or shortly thereafter.

Columbia University is an *Affirmative Action/Equal Opportunity Employer.*

Ohio State University/Paleobiologist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a paleobiologists with a strong quantitative background; and the capacity to develop or expand a research program in biogeography, evolutionary paleobiology, functional morphology, or paleoecology that will augment existing programs in biostratigraphy, mikropaleontology and sedimentary petrology.

Ph.D. or equivalent is required by the time of appointment. The successful applicant will be expected to teach graduate and undergraduate courses appropriate to their expertise, conduct research and supervise graduate students. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Walter C. Sweet
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-2326 or 422-8746

Applications should include a resume, a statemen of research record and interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

The Ohio State University is an equal opportunity/affirmative action employer.

Ohio State University/Structural Geologist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a structural geologist with a strong background in quantitative analysis of field data and research interests in regional tectonics or tectonophysics. The successful applicant will be expected to participate in the undergraduate program and give graduate courses in his/her field of expertise, conduct research, supervise graduate students, and interact with other departmental programs in regional geology and geophysics. Preference will be given to candidates with post-doctoral or industrial experience. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-5635 or 422-2721

Applications should include a resume, a statement of research interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

The Ohio State University is an equal opportunity/affirmative action employer.

The State University of New York at Binghamton/Petrologist. The State University of New York invites applications for a tenure-track faculty position in igneous or metamorphic petrology beginning August, 1984. Appointment will be at the level of assistant professor. Candidates must have a Ph.D. degree by this date, and also the potential to develop a productive research program, as well as teach at the undergraduate and graduate levels.

Applicants should send a resume and names of at least three persons who can be contacted for references to:

Thomas W. Donnelly
Department of Geological Sciences
State University of New York
Binghamton, New York 13901

The State University of New York at Binghamton is an affirmative action/equal opportunity employer. The closing date for this position is December 15.

Reflection Seismologists or Geologists. Bored by oil? BIRPS—academic seismic profiling at sea to 15 seconds—seeks postdocs for geological interpretation and innovative processing. Splendid environment. University salary. Send cv to Dr. Matthews, Earth Sciences, Bullard Labs, Cambridge University, England.

Assistant/Associate Professor (Ocean Engineering). Tenure-Track Position beginning 1984–1985 academic year. Preference given to candidates with expertise in 1 or more of the following areas: offshore and coastal structures, acoustic imaging (including subbottom studies), oceanographic remote sensing, wave dynamics sediment transport. Must establish an active sponsored research program, teach graduate courses in area of specialization and supervise graduate student research. Ph.D. or equivalent degree in specialty area required. Send resume, names and addresses of 3 references and a description of career goals by May 1, 1984 to: Dr. Malcolm L. Spalding, Chairman Search Committee, Department of Ocean Engineering, UNIVERSITY OF RHODE ISLAND, Kingston, R.I. 02881–0814.

An AA/EOE M/F.

Department of Geosciences/University of Houston. The Department of Geosciences is intercated in having applications for tenure track positions in the following areas: (1) Geophysics—seismology, exploration, data processing (2) Petrology—sandstones and metamorphic (3) Geochemistry—diagenesis

Salary and rank commensurate with experience.

If interested, please send:

(1) A curriculum vitae
(2) A brief statement of teaching and research interests
(3) Three letters of recommendation to:

Dr. John C. Butler
Department of Geosciences
University of Houston
Houston, Texas 77004

Affirmative-action/equal-opportunity employer.

Louisiana State University/Tenure-Track Faculty Positions in Geology. The Department of Geology is expanding from 15 to 35 faculty with four positions open Fall 1984 and one position (Field Camp Director) open January 1984. Candidates must have the Ph.D. and have active research in progress that might be applied to studies of basins. Specialties of primary interest are field geology, theoretical seismology, hydrogeology, and organic geochemistry; however, other disciplines will also be considered with quality of research being the primary factor in applicant selection. All faculty in the Department are required to conduct research leading to publications and to provide quality instruction. The Department will expand into a new building January 1986.

For consideration send resume, three letters of reference and a description of research to Lyle McGinnis, Faculty Search, Department of Geology, Louisiana State University, Baton Rouge, LA 70803–4101. Search will remain open until positions are filled.

LOUISIANA STATE UNIVERSITY IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY EMPLOYER.

Post-Doctoral Position in Isotopic Geochemistry-Department of Geology and Geophysics/University of Minnesota. Applications are invited for a postdoctoral appointment in geochemistry starting January 1, 1984. The candidate should have research interests and training in igneous petrology and isotopic and trace element geochemistry. The appointee is expected to work on problems related to mantle geochemistry and magma genesis, by application of Sm-Nd and Rb-Sr isotopic techniques and trace element geochemistry. Prior experience in solid source mass spectrometry is desirable. The duration of the initial appointment is for one year, with opportunities for renewal for a subsequent year or two. Starting salary is in the range of $17,000 to $19,000, based on previous experience. Candidates should submit a resume with the names of three references as well as a brief statement of research interests to:

V. Rama Murthy
Dept. of Geology and Geophysics
University of Minnesota
310 Pillsbury Drive S.E.
Minneapolis, MN 55455

The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

Cornell University Department of Geological Sciences. Applications are invited for a tenure-track position at the assistant professor level to begin in Fall 1984. Specialties of interest are sedimentology, stratigraphy, and structural geology. Some experience beyond the Ph.D. is desirable. Send curriculum vitae and names of three references to

Donald L. Turcotte, Chairman
Department of Geological Sciences
Kimball Hall
Cornell University
Ithaca, New York 14853

Cornell University is an Equal Opportunity Employer.

Physicist/Math Analyst. Sigma Data Services Corp., an M/A-COM Co., has an immediate opening for a Physicist/Math Analyst. Master's degree or equivalent experience in magnetospheric physics or solar terrestrial physics is required. Experience with spacecraft or rocket trajectory calculations is desired. Must have working knowledge of FORTRAN and have at least three years experience in the use of computers for data reduction or mathematical analysis. Duties include enhancement of existing programs, analysis, development, and implementation of new capabilities for determining multi-satellite, ground station, and magnetospheric model interactive data acquisition and analysis. Send resume to Dr. H. K. Hills, Sigma Data Services Corp., NASA/GSFC, Code 601, Greenbelt, Md. 20771 or call (301) 344-8105.

University of Alaska/Exploration Geophysicist—Seismic Stratigrapher. Applications are invited for a tenure-track teaching/research position in the Geology/Geophysics Program of the College of Environmental Sciences. Prime responsibilities will be to teach graduate and some undergraduate courses in the use of state-of-the-art techniques in petroleum exploration geophysics. The successful applicant will also develop an innovative research program to complement our growing petroleum geology curriculum. Doctorate is required. Industrial experience in hydrocarbon exploration and, in particular, the use of seismic reflection data to interpret stratigraphy and facies is desirable. The nine-month faculty position is open starting in January 1984. Rank and salary commensurate with qualifications and experience. Resume and at least three references should be submitted to Dr. Juan G. Roederer, Director, Division of Geosciences, University of Alaska, Fairbanks, Alaska 99701. Applications will be accepted until December 15, 1983 or until position is filled.

Your application for employment with the University of Alaska may be subject to Public Disclosure if you are selected as a finalist.

The University of Alaska is an EO/AA employer and educational institution.

Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011.

Iowa State University is an equal opportunity/affirmative action employer.

NASA NSSDC/ACQUISITION SCIENTISTS

Sigma Data Services Corp. a M/A-COM Company, as contractor operating the National Space Science Data Center (NSSDC) at NASA/GSFC, has immediate openings for scientists in the following disciplines:

—Astronomy/Solar Astronomy/Astrophysics (especially X-ray)
—Remote sensing/Meteorology/Atmospheric Sciences
—Lunar/Planetary Geology/Planetology
—Magnetospheric Physics

M.S. required, PhD preferred. Candidates should have experience in analysis of data from spacecraft experiments in their subject area. Working knowledge of FORTRAN is required. Incumbents will serve as acquisition agents for data archived at NSSDC, interface with investigators, and engage in data synthesis efforts, and the generation of data catalogs. Research opportunities available. Send resumes to Dr. H. K. Hills, Sigma Data Services Corp., NASA/GSFC Code 601; Greenbelt, Md. 20771 or call (301) 344-8105.

The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate level, and conduct research leading to schlorly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
Solid-Earth Geophysics
Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applications should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211

Trent University/Environmental and Resource Studies Program. The Trent Aquatic Research Group invites applications for a Research Associate with interest in movement of radioactive isotopes through aquatic ecosystems. Previous experience in lab and field research in low level isotope measurement or chemical speciation is required. Applicants should possess a Ph.D. in Applied Limnology, Chemical Engineering or equivalent. The position will commence on November 1, 1983. Send a letter of application with C.V. and copies of published papers to: Dr. R. D. Evans, Environmental Center, Trent University, Peterborough, Ontario, Canada.

Chairperson, Department of Geosciences/Texas Tech University. Applications and nominations are sought for the above position. Requirements are a doctoral degree in a suitable specialization within the geosciences, or equivalent experience, and a record that would warrant faculty appointment at the level of Associate Professor or Professor. Desired qualifications are an established record of scientific contributions including a productive current research program, experience in graduate and undergraduate teaching and in supervision of M.S. and Ph.D. students, proven ability to obtain external funding, and indication of strong administrative ability.

Texas Tech University is located in Lubbock, an urban community with a population of over 180,000. The University presently enrolls more than 23,000 students. The Department of Geosciences offers courses in atmospheric science, geochemistry, geology and geophysics. Degree programs include the B.A., B.S., M.S. and Ph.D. in geoscience, and M.S. in atmospheric science. The Department presently consists of approximately 250 undergraduate majors, and 16 faculty.

The position will be available August 1, 1984. The area of specialization is open, faculty rank and salary will be commensurate with qualifications. Applications and nominations should be sent to:

Chairperson Search Committee
Department of Geosciences
Texas Tech University
P.O. Box 4109
Lubbock, Texas 79409

Letters of application should include vita and names and addresses of 5 references. The closing date for applications is January 20, 1984.

Texas Tech University is an equal employment opportunity and affirmative action employer.

Geophysicist Tenure-Track Appointment/Department of Geology, University of Toledo. The position is effective September 1, 1984. Individuals with strong backgrounds in exploration geophysics—applied geophysics are of primary interest although other specializations will be considered. The Ph.D. is required as well as a strong commitment to effective teaching and research. The department has modern facilities and offers B.S., B.A., and M.S. degrees to approximately 80 undergraduate and 50 graduate students. The faculty consists of eight full time and five adjunct professors actively involved in a wide range of research pursuits. Interested persons should submit a letter of application, resume, transcripts, and three letters of recommendation to: Stuart L. Dean, Chairman of Search Committee, Department of Geology, University of Toledo, Toledo, Ohio 43606, phone (419) 537-2246 or (419) 527-2009.

University of Toledo is an equal opportunity/affirmative action employer.

Professor of Marine Geophysics Tectonics/Stanford University. The Department of Geophysics is seeking candidates for a tenure track position in the broad area of marine geophysics and tectonics. We seek a creative scientist with experience in gathering, interpreting, and synthesizing marine geophysical data and whose research interests cover depositional, igneous, and tectonic processes on oceanic plates and continental margins. Inquiries are invited from marine geophysicists with demonstrated scientific record in one of the above aspects of marine geophysics or tectonics, who have demonstrated an ability to develop new ideas and research directions, and to guide and teach graduate and undergraduate students. In considering this appointment we are interested in maximizing interactions with ongoing research groups in marine geology, plate tectonics, paleomagnetism, seismology and regional geology at Stanford. Our new faculty member will be expected to develop a strong research program involving both government and industrial participation.

Salary and rank will be commensurate with experience and background. Please submit a resume, a brief description of teaching and research interests, and references to:

Dr. Amos Nur
Department of Geophysics
321 Mitchell Building
Stanford University
Stanford, CA 94305

Stanford University is an equal opportunity employer, and encourages the application of qualified women and minorities.

POSITIONS WANTED

Physical Chemistry. Ph.D. specialized in Isotopic Geochemical Basic Research would consider challenging opportunity. P.O. Box 018 American Geophysical Union, 2000 Florida Avenue, N.W., Washington, DC 20009.

STUDENT OPPORTUNITIES

GRADUATE STUDENT NASA TRAINEESHIPS

The Florida State University is accepting applications from prospective graduate students for participation in its NASA sponsored Traineeship Program in Oceanographic Remote Sensing Techniques and Physics of Air-Sea Interaction. The stipend for the calendar year is $10,600. Students may be enrolled for a degree in either oceanography or meteorology. For further information or application, please write:

Dr. James J. O'Brien,
NASA Traineeship Program
Meteorology Annex
The Florida State University
Tallahassee, Florida 32306
(904) 644-4581

Meetings

Announcements

River Basins

The International Water Resources Association (IWRA) will hold a seminar at Linköping University in Sweden June 4–8, 1984, to discuss the relevance of the river basin approach to land and water management. The seminar will try to reach conclusions about plans for future actions using the river basin as the basic unit, specifically with regard to the criteria for environmental planning, for conflict resolution, and for developing coordinated land and water control.

Papers will deal with eight selected river basins and with four issues: river basins as ecosystems; legal and administrative issues; the problems of growing urban systems; and the problems of coordinating control and management of land and water resources.

Those interested in attending should contact Uhik Lohm, Water Theme, Linköping University, S-58183, Linköping, Sweden.

Offshore Minerals

A symposium to discuss plans for assessing and developing mineral resources in the recently proclaimed Exclusive Economic Zone off the coast of the United States will be held November 15–17 at the U.S. Geological Survey (USGS) National Center in Reston, Va. The symposium is being sponsored by the USGS, the Minerals Management Service, and the Bureau of Mines to aid in organizing a coordinated government, university, and industry effort to evaluate the potential mineral resources in the new zone; the zone was proclaimed on March 10, 1983, to extend U.S. mineral rights 200 miles offshore.

Presentations on current federal marine mineral resource activities will be followed by panel discussions on the science of resource assessment, the engineering technology involved, and the legal ramifications in developing these offshore minerals. The Secretary of the Interior is scheduled to be the keynote speaker; others from the White House, Congress, Department of Commerce, Navy, industry, and academia also will speak.

For additional information, contact the Assistant Secretary, Energy and Minerals, Department of the Interior, Washington, DC 20240 (telephone: 202-343-5691).

AGU Fall Meeting: Travel, Housing, Registration

The 1983 Fall Meeting of the American Geophysical Union will be held in San Francisco, Calif., December 5–9, at the Cathedral Hill Hotel and the Holiday Inn Golden Gateway Hotel. San Francisco is a dynamic, exciting city, known to the world for its spectacular scenery, fabulous restaurants, cosmopolitan life style, and gentle climate. It is a superb meeting location at any time of the year.

Registration

Everyone who attends the meeting must register. Preregistration (received by November 10) saves you time and money. The fee will be refunded to you if AGU receives written notice of cancelation by November 28. Registration rates are as follows:

	Preregistration	After Nov. 10
Member	$65	$80
Student member	$32	$47
Retired senior member (65 or over)	$32	$47
Nonmember	$90	$105
Student nonmember	$41.50	$56.50

Registration for 1 day only is available at one half the above rates, either in advance or at the meeting. Members of the American Congress on Surveying and Mapping, the American Meteorological Society, the American Society of Photogrammetry, the European Geophysical Union, and the Union Geofísica Mexicana, may register at the AGU member rates.

If you register as a nonmember for more than 1 day, the first-year dues for joining AGU will be waived if a completed application is received at AGU by Feb. 10, 1984.

To preregister, fill out the registration form, and return it with your payment to AGU by November 10. Your receipt will be included with your preregistration material at the meeting. Preregistrants should pick up their registration material at the registration desk at the Cathedral Hill Hotel. Hours are 8 A.M. to 4 P.M., Monday through Friday. On Sunday, December 4, registration hours are 5:30 to 7:30 P.M.

Hotel Accommodations

Blocks of rooms ($47 singles, $53 doubles) are being held at the Cathedral Hill, the Holiday Inn Golden Gateway, the Holiday Inn Civic Center, the San Francisco, and the Grosvenor Inn for those attending. Read the housing application, and mail the completed application form to the housing bureau early to ensure reservations at your preferred hotel. ***Reservation forms must be sent directly to the Housing Coordinator, AGU Fall Meeting, San Francisco Housing Bureau, P.O. Box 5612, San Francisco, CA 94101.*** Do not send housing reservation forms to the hotels.

Reservations must be received by November 1 to be confirmed. Do not write or call AGU for room reservations.

Free parking is available only to registered guests of each hotel as indicated.

Scientific Sessions

The program summary appears later in this issue. The preliminary program and the abstracts will be published in *Eos*, November 8. The final program, with presentation times, will be distributed at the meeting. Both the Cathedral Hill and the Holiday Inn Golden Gateway hotels will be used for all disciplines.

Poster Sessions Poster sessions will be held throughout the meeting in the Eldorado Room at the Cathedral Hill Hotel. Check the program for detailed scheduling. AGU will provide each poster-session presenter with a mounting area measuring 4 x 6 feet (1.25 x 2 m). Plan your exhibit to fit this space. The board will be assigned by number corresponding to the presenter's abstract number. The boards will be set up in the Eldorado Room before the poster session begins. Thumb tacks, push pins, tape, and scissors will be available in the meeting room.

Exhibits

The exhibits will be located on the Mezzanine, Cathedral Hill Hotel, Monday, December 5, through Thursday, December 8, 9:30 A.M. to 4:00 P.M.

The following exhibitors are confirmed:

Academic Press, Inc.
American Geophysical Union
Defense Mapping Agency/HTC
Digital Imaging Processing
EG&G Geometrics
Elsevier Science Publishing Co.
Handar
Jet Propulsion Laboratory
Kinemetrics
Nature's Own
Phoenix Geophysics
Qualimetrics, Inc.— WEATHERtronics
Refraction Technology
Schonstedt Instrument Co.
Sprengnether Instruments
Springer-Verlag, New York
Teledyne Geotech
Terra Technology
U.S. Geological Survey

Social Events

An icebreaker party on Monday evening on the Mezzanine at the Cathedral Hill Hotel will be the opening social event of the meeting. To honor John W. Handin, the 1983 recipient of the Bucher Medal, and those 1983 AGU Fellows who were not present at the 1983 Spring Meeting, there will be an awards ceremony and wine tasting reception on Thursday evening, 6:00–7:30 P.M., in the

Meetings *(cont. on p. 602)*

RETURN THIS FORM WITH PAYMENT TO:

Meeting Registration
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009

PLEASE PRINT CLEARLY

NAME ON BADGE _____

AFFILIATION _____

MAILING ADDRESS _____

_____

_____

TELEPHONE # _____

HOTEL

_____

Days you plan to attend
Please check the appropriate box(es)
☐ Dec. 5 ☐ Dec. 6 ☐ Dec. 7
☐ Dec. 8 ☐ Dec. 9

Please check appropriate box
☐ Member AGU ☐ Nonmember

Members of the cooperating societies may register at AGU member rates

Member cooperating society:
☐ AMS-American Meteorological Society
☐ ASP-American Society of Photogrammetry
☐ ACSM-American Congress on Surveying and Mapping
☐ EGU-European Geophysical Union
☐ UGM-Union Geofísica Mexicana

Nonmembers

If you register as a nonmember for more than 1 day, the first-year dues for joining AGU will be waived if a completed application is received at AGU by Feb. 10, 1984.

Preregistrants

Your receipt will be in your preregistration packet. The registration fee will be refunded if written notice of cancelation is received in the AGU office by November 28. The program and meeting abstracts will appear in the November 8 issue of *Eos*.

AGU 1983 FALL MEETING
DECEMBER 5-9
San Francisco, California

REGISTRATION FORM

Deadline for Receipt of Preregistration NOVEMBER 10, 1983

(rates applicable only if received by November 10 with payment)

	More than one day	One day
MEMBER	☐ $65	☐ $32.50
STUDENT MEMBER	☐ $32	☐ $16
RETIRED SENIOR MEMBER*	☐ $32	☐ $16
NONMEMBER	☐ $90	☐ $45
STUDENT NONMEMBER	☐ $41.50	☐ $20.75

*65 or over

SECTION LUNCHEONS/DINNER

Circle section and indicate number of tickets. All lunches begin at noon. SPR dinner begins at 6:30 P.M.

____ Planetology/Volcanology, Geochemistry and Petrology, Tuesday, $9
____ Seismology/Tectonophysics, Tuesday, $5
____ Geomagnetism and Paleomagnetism, Wednesday, $5
____ Hydrology, Wednesday, $9
____ Ocean Sciences, Wednesday, $9
____ Solar-Planetary Relationships, Wednesday, $20 (dinner)
____ Atmospheric Sciences, Thursday, $9
____ Geodesy, Thursday, $9

Total Enclosed $ _____
(All orders must be accompanied by payment or credit card information. Make check payable to AGU.)

Charge to: ☐ American Express ☐ Visa ☐ Master Card

Card Number _____
Master Card Interbank No. _____
Expiration Date _____
Signature _____

Office Use
Code _____
Check _____

FIELD TRIP FORM

I wish to attend the Franciscan Nuno-terrane field trip on Sunday, December 4. My check for $25 is enclosed.

In case I am not among the first 40:

☐ I wish to be put on the waiting list. (If you don't go, money will be returned on the day of the trip.)

☐ I wish my money returned.

Signature _____ Print Name _____

Date _____

Address _____

_____

Telephone _____

Mail form to: M. C. Blake, Jr., Mail Stop 75, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025

HOTEL ACCOMMODATIONS

PARTICIPATING HOTELS

Cathedral Hill Hotel
Van Ness at Geary Street
(800) 227-4730

Holiday Inn Golden Gateway
1500 Van Ness Avenue
(415) 441-4000

Grosvenor Inn
Van Ness and Geary
(415) 673-7411

Holiday Inn Civic Center
50 8th Street
(415) 626-6103

San Franciscan Hotel
1231 Market Street
(415) 626-8000

ROOM RATES FOR ALL HOTELS

Single $47
Double $53
Twin $53

Suites available upon request

PARKING: **Cathedral Hill Hotel:** free to registered guest
Holiday Inn Golden Gateway: free to registered guest
San Franciscan Hotel: free to registered guest

All hotel reservations must be made on the housing form by November 1, 1983. No telephone requests will be accepted. Confirmations will be mailed directly to registrants by the individual hotels. After confirmation has been received, changes and cancelations should be made directly to the hotel.

Mail your completed form directly to:

Housing Coordinator
AGU Fall Meeting
San Francisco Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

American Geophysical Union
1983 FALL MEETING

HOUSING REGISTRATION FORM

READ CAREFULLY and RETURN FORM DIRECTLY TO THE SAN FRANCISCO HOUSING BUREAU AT THE FOLLOWING ADDRESS:

Housing Coordinator
AGU Fall Meeting
SF Housing Bureau
P.O. Box 5612
San Francisco, CA 94101

Please print or type all information, abbreviating as necessary. Confirmation will be sent by the hotel to the individual named in Part I. If more than one room is required, this form may be photocopied.

Part I

REQUESTOR
Last Name _____ First _____

Name of Company or Firm _____

Street Address or P.O. Box Number _____

City _____ State/Prov. _____ Zip-U.S.A. _____

Country _____ Telephone Number _____

Part II

INSTRUCTIONS: Select *THREE* hotels of your choice from the list of participating facilities, then enter the name on the lines below.

First Choice _____ Second Choice _____ Third Choice _____

NOTE: Rooms are assigned on a "First Come, First Served" order, and if none of your choices is available, another facility will be assigned based on a referral system. A cut-off date is in effect; your application may not be processed if received after 14 days prior to your arrival date. **AGU housing registration deadline is November 1.**

Part III

INSTRUCTIONS: 1. Select type of room desired with arrival and departure dates.
2. *PRINT* or *TYPE* names of *ALL* persons occupying room.
3. If more than two persons share a room, check twin and the hotel will assign two double beds.

CHECK ONE		Guest Names (Last name first)
☐ SINGLE (Room with one bed one person)	Arrival Date _____	1. _____
☐ DOUBLE (Room with one bed two persons)	Arrival Time _____ AM/PM	2. _____
☐ TWIN (Room with two beds two persons)	Departure Time _____	3. _____
☐ EXTRA PERSON		4. _____

IMPORTANT NOTE: Hotel MAY require a deposit or some other form of guaranteed arrival. If so, instructions will be on your confirmation form.

Meetings *(cont. from p. 601)*

Emerald Ballroom of the Holiday Inn Golden Gateway. All meeting participants are invited to attend.

Complimentary refreshments will be served daily, at both hotels, 9:15–11:00 A.M. and 2:15–4:00 P.M.

Business Meetings and Section Luncheons/Dinner

The AGU Council will meet Tuesday, December 6, at 5:30 P.M., in the Japanese Pavilion Room, Cathedral Hill Hotel.

The section lunches and dinner will be held at the following restaurants: Nikko, at Van Ness and Pine; Casa de Cristal, 1122 Post Street; A. Sabella's, on Fisherman's Wharf; and the Holiday Inn Golden Gateway. Purchase your ticket now as space is limited.

Tuesday, December 6

- Planetology and Volcanology, Geochemistry, and Petrology, Noon, Casa de Cristal, $9.
- Seismology and Tectonophysics, Noon, Nikko, $5. Sponsors, Kinemetrics, Inc., Teledyne Industries, Inc., W. F. Sprengnether Instrument Co., Inc.

Wednesday, December 7

- Geomagnetism and Paleomagnetism, Noon, Casa de Cristal, $5. Sponsors, Schonstedt Instrument Company, CFT Systems.
- Hydrology, Noon, Holiday Inn Golden Gateway, $9.
- Ocean Sciences, Noon, Nikko, $9. Program: Gordon Hamilton, Office of Naval Research, will speak on "ONR's Environmental Science Program."
- Solar-Planetary Relationships, business meeting, with dinner to follow, at A. Sabella's Restaurant, 5:15 P.M., business meeting, Emerald Room, Holiday Inn Golden Gateway, 6:45 P.M., dinner, A. Sabella's, $18.50 (Italian gourmet).

Thursday, December 8

- Atmospheric Sciences, Noon, Nikko, $9.
- Geodesy, Noon, Holiday Inn Golden Gateway, $5. Sponsor, Bell Aerospace Textron.

Field Trip

On Sunday, December 4, 9 A.M. to 5 P.M., in connection with the Nano-Plate-Tectonic Symposium, there will be a field trip to the Franciscan nano-terranes in San Francisco, stressing their contact relations. The trip will be led by Clark Blake and Clyde Wahrhaftig.

The $25 per-person cost includes tour bus, lunch, and field trip guide.

The trip, which will leave from and return to the Cathedral Hill Hotel, will be limited to 40 persons, and space will be reserved for the first 40 to sign up. Others can be put on a waiting list, or their checks can be returned, as they wish. Those interested should send the form printed in this issue with a check made out to M. C. Blake, Jr., addressed as indicated on the form. Be sure to mark on outside of the envelope "For AGU Dec. Field Trip."

Program Summary

Union
Orinoco & Amazon, Tues AM
Computers & Geosciences, Tues PM
Nuclear Consequences, Wed AM
Polar Research, Thurs AM

Atmospheric Sciences
Lightning, Mon PM
Thunderstorms, Tues AM
CCOPE, Tues PM
Effects of Nucl. Bursts, Wed PM
Troposph. Chemistry I, Thurs PM
Troposph. Chemistry II, Fri AM
Climate & Chemistry, Fri PM

Geodesy
LAGEOS I, Mon AM
LAGEOS II, Mon PM
Earth Rot./Orient., Tues AM
Oceans/Geodesy/Tect., Wed PM
Crustal Dynamics I, Thurs AM
Crustal Dynamics II, Thurs PM
GPS & Gravity, Fri AM

Geomagnetism & Paleomagnetism
Theory & Anisotropy, Mon AM
Recognizing Alteration, Mon PM
Sec. Variat., Excursion, Tues AM
Calif., Baja to Sur, Tues PM
Oregon to Alaska, Wed AM
Paleopoles & APW Curves, Wed PM
Statistics & Sounding, Thurs AM
Melts & Conduct. Paths, Thurs PM
Magnetotell. Variat., Fri AM

Hydrology
Glacier/Ocean Interact., Mon AM
Streamwater Geochem., Mon PM
Orinoco & Amazon I, Tues PM
Gen. Hydrol. Poster Sess., Tues PM
Orinoco & Amazon II, Wed AM
Instream Flow, Wed AM
General Groundwater I, Wed AM
Sediment Transport I, Wed AM
Gen. Hydrol./Stochastic, Wed PM
Sediment Transport II, Wed PM
Multivariate Models I, Thurs AM
Groundwater Optimization, Thurs AM
Multivariate Models II, Thurs PM
General Hydrology, Thurs PM
Watershed Models, Fri AM
Floods I, Fri AM
General Groundwater II, Fri PM
Floods II, Fri PM

Oceanography
Geochemistry of Estuaries, Mon AM
CODE/OPUS/SUPER-CODE, Mon AM
El Niño, '82-'83, Mon PM
MANOP, Mon PM
Hydrothermal Vents, Tues AM
Calif. El Niño, '82-'83, Tues AM
Coastal Oceanography, Tues PM
Seabed Morphology, Wed AM
Physical Oceanography, Wed AM
Diagenesis in DSDP, Wed PM
Marine Chemistry, Thurs AM
General Circulation, Thurs PM
Paleoceanography, Fri AM
Response to Strong Wind, Fri AM
Sub-seabed Disposal, Fri PM
Marginal Seas, Fri PM

Planetology
Surfaces & Atmospheres, Wed PM
Satellites & Cratering, Thurs PM

Seismology
Coalinga Earthquake, Mon AM
Mostly Nuclear, Mon AM
Rio Grande Rift, Mon PM
Lateral Heterogeneity, Mon PM
Oceanic Lithosphere I, Tues AM
Earthquake Chemistry, Tues AM
Oceanic Lithosphere II, Tues PM
Earthquake Hydrology, Tues PM
Earthquake Prediction, Tues PM
Crust & Upper Mantle I, Wed AM
Crust & Upper Mantle II, Wed PM
Marine Seismology, Wed PM
Sources & Strong Motion, Wed PM
Future Global Network, Wed PM
Seismicity & Tectonics I, Thurs AM
Wave Propagation I, Thurs AM
Seismicity & Tectonics II, Thurs PM
Wave Propagation II, Thurs PM
Long Period Seismology, Fri AM
Tomography/Networks, Fri PM

SPR: Aeronomy
Ionosphere: Radar, Mon PM
Ionosphere, Tues AM
Airglow-Aurora Poster, Tues AM
Middle Atmosphere, Tues PM
Mesosph.-Thermosph. I, Wed AM
Mesosph.-Thermosph. II, Wed PM
Mesosph.-Thermosph. III, Thurs AM
Airglow, Thurs PM
Euv-Airglow I, Fri AM
Euv-Airglow II, Fri PM

SPR: Cosmic Rays
Cosmic Rays, Mon AM
IMP 7 & 8, Mon PM
IMP 7 & 8, Tues AM

SPR: Magnetospheric Physics
Aurora/Substorms I, Mon AM
AMPTE Program I, Mon AM
Jupiter/Saturn, Mon AM
Aurora/Substorms II, Mon PM
AMPTE Program II, Mon PM
Reconnection, Tues AM
Aurora/Substorms III, Tues AM
Electric Currents/Fields, Tues AM
Compar Planet Msph I, Tues PM
Compar Planet Msph II, Wed AM
VLF Waves, Wed AM
History of VLF Research, Wed PM
Spacecraft Effects I, Wed PM
Ion Composition/Dynamics, Thurs AM
Spacecraft Effects II, Thurs AM
Magnetic Pulsations I, Thurs AM
Charged Particles I, Thurs PM
Waves/Instabilities I, Thurs PM
ISEE-3 in Magnetotail I, Fri AM
Waves/Instabilities II, Fri AM
Auroral Hiss & AKR, Fri AM
Magnetic Pulsations II, Fri AM
Charged Particles II, Fri AM
ISEE-3 in Magnetotail II, Fri PM
Magnetospheric Tail, Fri PM
Ionospheric Radars, Fri PM
Waves/Instabilities III, Fri PM

SPR: Solar & Interplanetary Physics
Solar Phenomena, Tues AM
Solar Wind, Tues PM
Shocks/Upstream Phenomena, Wed AM
Solar Physics, Wed PM
Solar Wind Int. w/ Comets, Thurs AM
S.W. Int. w/ Venus/Titan, Thurs PM

Tectonophysics
Tect. Sed. Active Marg. I, Mon AM
Fault Zone Drilling I, Mon AM
Marine Tectonics, Mon AM
Tect. Sed. Active Marg. II, Mon PM
Fault Zone Drilling II, Mon PM
Heat Flow, Mon PM
Mantle/Crustal Dynamics, Tues AM
Deformation, Tues AM
Tectonic Hazards, Tues PM
Tectonics: General, Tues PM
Recent Trends, Wed AM
Active Margins, Wed AM
High Pressure Research, Wed AM
Physics of Magma Transfer, Wed PM
Fracture & Faulting, Wed PM
Rift Research, Wed PM
Active Tectonics I, Thurs AM
East Pacific Rise, Thurs AM
Tectonics Poster Session, Thurs AM
Active Tectonics II, Thurs PM
Himalayan-Alpine, Thurs PM
Tectonophys. Poster Sess., Thurs PM
Salton Sea Drilling, Fri AM
California Tectonics, Fri AM
Circum-Pac. Tectonics: SE, Fri AM
Franciscan Geology SF Bay, Fri PM
Phys., Chemistry Minerals, Fri PM
Circum-Pac. Tectonics: N, Fri PM
Circum-Pac. Tectonics: SW, Fri PM

Volcanology, Geochemistry, & Petrology
Calderas I, Mon AM
Mineral Physics I, Mon AM
Calderas II, Mon PM
Metamorphism, Mon PM
Calderas III, Tues AM
Gases, Tues AM
Calderas IV, Tues PM
Ore Deposits, Tues PM
Cascades I, Wed AM
Laki Bicentennial, Wed AM
Calderas V, Wed PM
Arc Volcanism, Wed PM
Cascades II, Thurs AM
VGP Potpourri, Thurs PM
Cascades III, Thurs PM
Hawaii I, Fri AM
Mantle Petrology, Fri AM
Hawaii II, Fri PM
Isotopic Studies, Fri PM

Air Fare Information

Special AGU Discounted Air Fares Available When You Fly UNITED to San Francisco

Your toll-free number for flight reservations: 800-521-4041 (Michigan residents 800-482-0243)

Your AGU Convention Number 4367

Special arrangements have been made with United Airlines to offer you a $10 discount off Super Saver fares with the 7-day minimum stay requirements waived . . . only available when you call the unlisted, toll-free number of United's Convention Desk: 8:30 A.M.–5:30 P.M. EST, Monday–Friday.

Just call the above number, available to those within the 48 contiguous states. Ask for the Convention Desk. Tell them you are attending the AGU convention in San Francisco or give them AGU's convention number: 4367.

Here are the details on your special AGU convention fare:

- $10 discount on the roundtrip Super Saver/coach fare in effect at the time of travel.
- The 7-day minimum stay is NOT required.
- Travel must commence no earlier than December 1, 1983, and must be completed on or before December 12, 1983.
- Reservations should be made as early as possible. The final date for reservations and ticketing is the day before departure. Reservations will be accepted after this date, but at the higher fare.
- Ticket purchase may be made directly from United; they will mail your tickets direct to you. Just provide your form of payment when you call. If you wish to purchase your ticket through an authorized travel agency, you may do so. However, YOU, not your travel agent, should call United's unlisted number.

Special Note

In the current "air fare war" there may be sporadic and short-lived discounted fares from specific cities to San Francisco. These fares have restrictions and are limited. United's convention specialists will assist you in determining if your travel plans meet these specific restrictions.

AGU and United Airlines are working together to bring you a better meeting for less. Use the United Convention Desk; help yourself and AGU at the same time.

Chapman Conference on Collisionless Shock Waves in the Heliosphere

February 20–24, 1984
Silverado Country Club and Resort
Napa Valley, California

Convenor: R. G. Stone

Abstract Deadline:
November 22, 1983

Invited reviews and contributed papers in the following general areas: Overview of the collisionless shock, macroscopic aspects of shocks, microscopic aspects of shocks and particle acceleration. Typical subjects to be covered include:

- Why and where shocks form in the heliosphere?
- Shock dynamics and evolution.
- Shocks associated with solar activity, planetary bow shocks, coronation shocks, and shock-shock interactions.
- Subcritical, supercritical, quasi-parallel, and quasi-perpendicular shocks.
- Dissipation mechanisms.
- The foreshock.
- Particle acceleration mechanisms.

Student Travel Assistance: Deadline November 30. Student travel funds are available. To apply, write to Shock Waves Meeting, AGU, giving your educational background and your research interests.

Publication: A proposal for the publication of the invited papers as a monograph is under consideration by the AGU Monograph Board. It has also been recommended that the contributed papers be published as a separate monograph or be submitted to JGR-Space Physics through the normal AGU peer review process.

Contact: AGU Meetings, 2000 Florida Avenue, N.W., Washington, DC 20009
toll free: (800) 424-2488 D.C. area 462-6903

Call for papers published in EOS, May 31, 1983

Awards Ceremony and Reception

Thursday, December 8
6:00 - 7:30 p.m.
Emerald Ballroom, Holiday Inn

To honor John W. Handin, the 1983 recipient of the Bucher Medal, and those 1983 AGU Fellows who were not present at the Spring Meeting there will be an awards ceremony and wine-tasting reception. All meeting participants are invited and urged to attend.

AGU

Section Candidates

Eos is carrying biographies and photographs of all candidates for President-elect, General Secretary, and Foreign Secretary of the Union and for President-elect and Secretary of each Section. In addition, statements by the candidates for Union offices and for Section President-elect will appear. Candidates for the Seismology Section and an additional candidate for the Planetology Section appear below. The material for the sections of Geodesy, Geomagnetism and Paleomagnetism, and Planetology appeared in the August 30 issue; for the Atmospheric Sciences Section in the September 27 issue; and for the Tectonophysics Section in the October 11 issue. The slate of candidates for all offices was carried in the June 21 issue.

Seismology: President-elect

F. A. Dahlen A member of AGU since 1968; 40 years old. Professor of Geophysics, Princeton University. Major interests: theoretical seismology and mechanics, free oscillations, rotation of the earth. B.S. in geophysics, Caltech, 1964; Ph.D. in geophysics, UCSD, 1969. At Princeton since 1970. Member AGU, SSA, RAS. On editorial board of *The Geophysical Journal* 1977–1979; NSF Earth Sciences Panel 1982–83; 39 publications, 6 in AGU journals. Alfred P. Sloan Foundation Fellow 1971–1973. Candidate Stewart W. Smith (see below) taught Dahlen's first course in geophysics and provided his first summer job in geophysics.

Statement

"The Seismology Section of AGU is currently in very capable and distinguished hands, and I do not envision initiating any *major shifts* in policy if elected. I would use the 2-year term as President-elect to become better informed about the affairs of the Section and the Council, by soliciting the views and advice of the membership and the present and past officers of the Section. The principal function of AGU is to foster scientific communication through its program of meetings, conferences, and journals. I would be opposed to any significant change in format of the annual meetings despite the obvious problems caused by increasing attendance, because they provide such a valuable forum for students and others entering the field to discuss their work and meet their peers and colleagues. The AGU journals are healthy and highly respected, and it is important they remain so. Submission of papers in electronically encoded form, an option recently adopted by the journals of the APS, should be investigated. This would be particularly valuable for heavily mathematical articles requiring careful proofreading."

Stewart W. Smith A member of AGU since 1959; 50 years old. Professor of Geophysics, University of Washington. Major interests: seismicity, tectonics, and crustal deformation. S.B. in geology, MIT, 1954; Ph.D. in geophysics, Caltech, 1961. Geophysicist, Shell Oil Company, 1954–1957; Assistant and Associate Professor, Caltech, 1961–1970; Professor and Chairman of Geophysics, University of Washington, 1970–1980. Member SSA, EERI, SEG. Has been chairman, Geophysics Advisory Panel AFOSR, Director of SSA, on editorial committee of *Annual Review of Earth and Planetary Sciences*, on Seismology Committee on NAS/NRC, and served on advisory committees and panels for USGS, USNRC, EERI, IASPEI, and NSF; 41 publications, 11 published by AGU. Served as Program Chairman for AGU Seismology Section.

Statement

"The primary objective of AGU, and our Section in particular, is to provide communication within the scientific community and to the general public. I view the most important function of AGU officers to be the review and evaluation of the mechanisms by which we achieve this communication to determine if they are meeting our needs. Beyond the journals, newsletter, symposia, and general meetings, we need to be prepared to utilize the new tools that technology can provide to store, catalog, and transmit information. Ultimately the progress of our field will depend on how effectively we can learn from each other. I would hope that AGU will be at the forefront in the application of the next generation of communications and knowledge based systems to achieve this result."

Seismology: Secretary

William L. Ellsworth A member of AGU since 1972; 34 years old. Chief, Branch of Seismology, U.S. Geological Survey, Menlo Park, Calif. Major interests: earthquake seismology and lithospheric structure. B.S. in physics and M.S. in geophysics, Stanford University, 1971; Ph.D. in geophysics, MIT, 1978. U.S. Geological Survey since 1971. Member AGU, SSA, SEG, Sigma Xi, and IMGS. Member of Panel on Seismological Studies of the Continental Lithosphere of NAS/NRC; served on advisory panels for U.S. Nuclear Regulatory Commission and Committee on Seismology, NRC; 17 publications, 7 published by AGU.

Emilo A. Okal A member of AGU since 1974; 33 years old. Associate Professor of Geology & Geophysics, Yale University (as of January 1, 1984; Associate Professor of Geological Sciences, Northwestern University). Major interests: seismology, plate tectonics, intraplate volcanism, marine geophysics. M.S., Ecole Normale Supérieure and University of Paris, 1972; Ph.D. in geophysics, Caltech, 1978. Came to U.S. in 1974; naturalized in 1982. Faculty member at Yale since 1978; will move to Northwestern January 1, 1984. Member: AGU, SSA. About 40 publications, 7 in AGU journals. Associate Editor, JGR-Red. 1983–1985; Program Chairman for Seismology, AGU Spring Meeting, 1983 and 1984.

Planetology Petition Candidate: Secretary

Gregory F. Herzog has been approved as an additional candidate for Secretary of the Planetology Section.

Gregory F. Herzog A member of AGU since 1971; 39 years old. Associate Professor, Department of Chemistry, Associate member, Graduate Program, Department of Geology, Rutgers University. Major interests, meteoritics. B.A., 1964, Cornell University; M.A., 1965, Ph.D., 1970, Columbia University; Resident Associate, University of Chicago, 1969–1971. Since 1971, Department of Chemistry, Rutgers University. 1976–1977 Max-Planck-Institut für Kernphysik, Heidelberg. Member AGU, AAAS, Meteoritical Society, XRF User Subgroup Representative, National Sync. Light Source. Associate Editor, 12th Lunar and Planetary Science Conference. 32 publications, 6 published by AGU.

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Paul Michael Abrahams (S), Guangfen Cheng (O), Donald Galya (O), Jeremy R. Henderson (S), Peter Hufschmied (H), Dieter M. Imboden (O), David R. Jones (V), Stephen Lane (S), W. G. Large (O), Denis Lefaivre (O).

Student Status

Debao Bai (A), Cecilia Binig (T), Richard A. Degner (S), Hjalmar Eysteinsson (GP), John R. Farver (V), Vanessa L. Griffin (M), Eugene O. Humphreys (S), Eugene S. Ilton (V), Richard A. Iverson (H), Carlos Krepper (O).

GAP

Separates

To Order: The order number can be found at the end of each abstract; use all digits when ordering. Only papers with order numbers are available from AGU. *Cost:* $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order. Deposit accounts available.

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Washington, D.C. 20009

Electromagnetics

0770 Radio Oceanography
ATTENUATION RATES OF COASTAL RADAR SIGNALS AT 25 MHz
R.D. Lyons (Wave Propagation Laboratory, NOAA/ERL, Boulder, Colorado 80303), D.E. Barrick (Ocean Surface Research, Boulder, Colorado 80303)

The attenuation rate of the ground-wave signal with range is a factor limiting the performance of coastal HF radars (OCEANAV). We show that observed attenuation rates are less than theoretically predicted rates at 25 MHz. This result, contrary to earlier findings at lower frequencies, suggests the onset of tropospheric ducting above 20 MHz. The attenuation rates for various sea states and distances are tabulated to allow estimates of system performance near 25 MHz. (Ground-wave attenuation, radar propagation)

Rad. Sci., Paper 3S1557

0773 Remote Sensing
DIFFERENTIAL REFLECTIVITY AND CIRCULAR POLARIZATION RADAR SIGNALS AND RELATED DROP OSCILLATION AND PROPAGATION EFFECTS IN RAINFALL
T. A. Seliga (Atmospheric Sciences Program and Department of Electrical Engineering, Ohio State University, Columbus, Ohio 43210), K. Aydin and V. N. Bringi
Differential reflectivity (Zdr) and circular depolarization ratio (CDR) radar signals are directly related to each other and to the median drop size diameter of rainfall when the drop sizes are exponentially distributed. These polarization parameters are sensed for both static and oscillating raindrop shapes along with their relationships with rainfall rate and liquid water content estimates derived from Zdr or CDR and reflectivity factor (Z) measurements. Propagation effects at S band wavelengths are also considered and shown to be particularly important in CDR measurements. (Differential reflectivity, radar meteorology, aircraft particle measurements, gyrogel).

Rad. Sci., Paper 3S0831

0773 Remote Sensing
ANALYSIS OF AIRCRAFT HYDROMETEOR SPECTRA AND DIFFERENTIAL REFLECTIVITY (ZDR) RADAR MEASUREMENTS DURING THE COOPERATIVE CONVECTIVE PRECIPITATION EXPERIMENT
V. N. Bringi (Department of Electrical Engineering, Colorado State University, Ft. Collins, Colorado 80523), T. A. Seliga and K. A. Cooper

Radar measurements of Zdr are compared with Zdr deduced from aircraft gyrogel spectra during the Cooperative Convective Precipitation Experiment. On August 4, 1981, the University of Wyoming's Super King Air made two penetrations (at altitudes of 3 km and 1.8 km above mean sea level) through a convective cell located 90 km NE of the CHILL radar. The aircraft was equipped with two two-dimensional PMS probes located orthogonally so as to view the falling hydrometeors along their symmetry axis (V probe) and along an axis orthogonal to it (H probe). Elliptical raindrop images were observed below cloud base (1.8 km altitude), and conical graupel images were observed at 3 km altitude. Because of beam blockage at the lowest elevation scans, radar data were not available in the rain region. Aircraft raindrop spectra were analyzed in detail, and it is shown that Zdr deduced from such spectra should be an excellent estimator of Dm provided the correct form for the drop size distribution is assumed. Zdr and Zh deduced from the gyrogel spectra are shown to be in the range measured by the radar. (Differential reflectivity, radar meteorology, aircraft particle measurements, gyrogel).

Rad. Sci., Paper 3S0821

0773 Remote Sensing (Multispectral Passive Microwave)
A SUMMARY OF RESULTS FROM THE FIRST NIMBUS-7 SMMR
P. Gloersen (Code 912, Goddard Laboratory for Atmospheric Sciences, Goddard Space Flight Center, Greenbelt, Maryland 20771), D.K. Cavalieri, A.T.C. Chang, T.T. Wilheit, W.J. Campbell, O.M. Johannessen, K.B. Katsaros, E.G. Njoku, W.L. Smith, H.R. Stanley, C.T. Swift, L.S. Fedor, R.F. Kunzi, D.B. Ross, D. Staelin, E.P.L. Hodson, T.C. Bartolo, P. Gudmandsen, E. Langham, and R.O. Ramseier
Selected data obtained during the first year of operation of the Scanning Multichannel Microwave Radiometer (SMMR) on board the Nimbus-7 satellite launched in late October 1978 have been used to calculate on a global basis seasonal geophysical parameters over open oceans, polar regions, and terrain. Over open oceans, these calculations have provided inferred values for sea surface temperatures, near-surface winds, atmospheric water vapor in a column, and rainfall rates. In polar regions, sea ice concentration, multiyear ice fraction, and radiating temperatures have been obtained. Finally, the extent and water equivalence of snow cover over terrain have been calculated. These retrieved snow parameters have been compared with in-situ measurements of the same geophysical parameters, where available, and the results of these comparisons are described. The self-consistency of the global displays of all the parameters is discussed, along with the plans for archiving them for subsequent research purposes. A description of the new calibration and data processing scheme is also given.

J. Geophys. Res., Ocean., Paper 3C1581

0740 Scattering
DIFFRACTION RADAR SCATTERING PROPERTIES OF HAIL HAIL AND MIXED-PHASE HYDROMETEORS
V. Aydin (Atmospheric Sciences Program and Department of Electrical Engineering, Ohio State University, Columbus, Ohio 43210), T. A. Seliga and V. N. Bringi
The differential reflectivity (ZDR) radar signal contains information on the shape and alignment of ice phase hydrometeors. Under certain circumstances, then, this signal and reflectivity factor can be used to identify the presence of hail particles. Such interpretations require knowledge about the scattering properties of various types and shapes of hydrometeors including ice, water-coated ice, and graupel. These properties are examined for their differential scattering properties obtained from computations using the transition matrix method of Waterman and an extension of this theory to two-layered bodies. Differential radar cross sections together with circular depolarization ratios are presented, and several instances of possible hail detection by radar using ZDR signatures are illustrated. (Scattering, radar meteorology, hail, differential reflectivity).

Rad. Sci., Paper 3S0819

Exploration Geophysics

0950 Seismic methods
VELOCITY ESTIMATES DERIVED FROM THREE-DIMENSIONAL SEISMIC DATA
Kwesi Owusu (Gulf Petroleum Co., One Lincoln Center, 5400 LBJ Freeway, Ste. 1200-LB 13, Dallas, TX 75240), G.R.F. Gardner and Wulf P. Hassell

A new computer algorithm is described by which velocity estimates can be derived from three-dimensional (3-D) multifold seismic data. The velocity estimate, referred to as "imaging velocity," is that which best describes the diffraction hyperboloid due to a scatterer. The scattering center is best imaged when this velocity is used in the reconstruction process.

The method is based on the 3-D Kirchhoff summation migration before stack. The implementation consists of two basic phases: (1) differentiating the input field traces and resampling them to a logarithmic time scale, and (2) shifting, weighting, and summing each resampled trace to a range of depth levels also chosen on a logarithmic scale. Peak amplitudes in the resulting image matrix give a time T and depth Z from which velocity is obtained using the relation $V=2Z/T$. The locus of constant velocity is a slanted straight line in the coordinate system of the matrix.

In the usual application of migration for velocity analysis, each input trace of N samples is migrated for each of N constant velocity functions requiring $N \times N$ moveout shift calculations. In the new method presented here, a constant shift is calculated for a given resampled trace, for each depth into which it is summed. This reduces the number of calculations per trace to about N, resulting in a significant improvement in computing efficiency.

The operation of the algorithm is illustrated using synthetic and physical model data.

GEOPHYSICS, VOL. 48, NO. 11

0930 Seismic methods
APPLICATION OF SEISMIC REFLECTION DATA TO DISCRIMINATE SUBSURFACE LITHOSTRATIGRAPHY
Anita Sinha (Formerly Department of Earth Sciences, University of Roorkee, India; presently National Geophysical Research Council Centre, Hills Road, Cambridge, CB2 2QH, India) Kailash Khattri

A correlation between lithology and quantitative parameters abstracted from seismic reflection data is established. The concept and methodology developed on synthetic data has been successfully applied to discriminate between two different kinds of lithologies. A particular hydrocarbon-bearing stratum in a sedimentary basin in Western India has been considered, part of which is dominantly sandy (lithological composition: sand = 53 percent, shale = 21 percent, coal = 26 percent) and another part which is dominantly shaly (sand = 37 percent, shale = 60 percent, coal = 3 percent). The two lithologies also have different seismic velocities and densities. The two lithologies are mathematically modeled using one-step Markov chains. Their seismic responses when convolved in time and frequency domain and subjected to statistical discriminant analysis give a fair idea about synthetic subsurface lithostratigraphy. Seismic reflection data from the same area were considered for a similar analysis. On subjecting the data to discriminant analysis, it was again possible to discriminate between the two lithologies. Also, seismograms from different areas of the same basin could be grouped in terms of subsurface lithostratigraphy. Certain features of subsurface lithostratigraphy have been identified, three of which were abstracted from the seismic reflection section and fed to form the test spectrum of the seismogram.

This analysis is a potential tool for diagnosing subsurface lithology from seismic data and for eliminating the tedious karrow surroundings in a preliminary manner.

GEOPHYSICS, VOL. 48, NO. 11

Geochemistry

1410 Chemistry of the Atmosphere
HYDROCARBON AND CARBON MONOXIDE EMISSIONS FROM BIOMASS BURNING IN BRAZIL
J. P. Greenberg (National Center for Atmospheric Research*, Boulder, Colorado 80307) P. R. Zimmerman, L. Heidt, and W. Pollock
Field measurements of hydrocarbon and carbon monoxide emissions from biomass burning in the cerrado (grasslands) and selva (tropical forest) regions of Brazil in 1979 and 1980 are characterized and quantified. Regional consequences of burning activities include elevated background mixing ratios of carbon monoxide and ozone, as well as reduced visibility, over extensive areas. Global extrapolation of the emission rates of hydrocarbons and carbon monoxide from these fires indicates that 6 x 10^{13} g C of gas phase hydrocarbons and 8 x 10^{14} g CO may be released annually from biomass burning. Those emissions contribute significantly to the global budgets of these gases. (Hydrocarbons, carbon monoxide, biomass burning).
*The National Center for Atmospheric Research is sponsored by the National Science Foundation.
J. Geophys. Res., Green, Paper 3C1539

1410 Chemistry of the atmosphere
TRACE METALS IN BERMUDA RAINWATER
T.D. Jickells (Bermuda Biological Station, Ferry Reach 1-15, Bermuda), A.H. Knap and T.M. Church
The concentrations of Cd, Cu, Mn, Ni, Pb and Zn have been measured in Bermuda rainwater. Factor analysis indicates that Fe, Mn and Pb have similar origins to acidic components derived from North America. The other metals all behave similarly, but differently to the acids. Sea-salt, even after allowances for fractionation, contributes minor amounts of Cu, Pb and Zn and uncertain amounts of Fe, Mn and Cd to Atlantic ocean precipitation.
Wash-out ratios, calculated from this data along with earlier measurements of atmospheric trace metal concentrations on Bermuda, are of the same order as those reported from other remote ocean areas. The wet depositional fluxes of Cu, Ni, Pb and Zn to the western north Atlantic ocean are significant compared to measured oceanic flux rates. However, the wet depositional fluxes of Fe and Mn to this area are relatively small suggesting additional inputs, while an excess wet depositional flux of Cd suggests large scale atmospheric recycling of this element. (Rainwater, trace metals, Bermuda).
J. Geophys. Res., Green, Paper 3C1603

1410 Chemistry of the Atmosphere
SEASONAL VARIATION OF METHANE FLUX FROM A CALIFORNIA RICE PADDY
R. J. Cicerone (National Center for Atmospheric Research*, P.O. Box 3000, Boulder, CO 80307), J. D. Shetter, and C. C. Delwiche
To allow increased understanding of the global budget of atmospheric methane, individual methane sources require investigation. We have measured methane emissions from a California rice paddy during the entire 1982 growing season. A very strong seasonal dependence was observed. Methane emissions were highest in the last 2-3 weeks before harvest; daily emissions reached 5 gCH_4/m^2. Over the 100-day season, daily emissions averaged about 0.25 gCH_4/m^2, higher than our previously reported values. Attempts to estimate global rice-paddy emissions must recognize the possibility of seasonal variations. Soil temperature at 10 cm depth correlated poorly with our measured fluxes; soil redox potential was a more reliable indicator.
*The National Center for Atmospheric Research is sponsored by the National Science Foundation.
J. Geophys. Res., Green, Paper 3C1569

1410 Chemistry of the Atmosphere
VALIDATION OF NITROGEN DIOXIDE RESULTS MEASURED BY THE LIMS INFRARED MONITOR OF THE STRATOSPHERE (LIMS) EXPERIMENT ON NIMBUS 7
J. M. Russell III (NASA Langley Research Center, Mail Stop 401A, Hampton, Virginia, 23665), J. C. Gille, E. E. Remsberg, L. L. Gordley, P. L. Bailey, S. R. Drayson, H. Fischer, A. Girard, J. E. Harries, and W. F. J. Evans
The LIMS experiment launched on Nimbus 7 measured vertical profiles of temperature and the concentrations of O_3, H_2O, HNO_3, and NO_2 during the period from late October 1978 until late May 1979. This paper discusses the validation of results from the NO_2 channel and the quality of the data. The discussion includes channel characteristics, experiment errors due to instrument and spacecraft effects, predicted and measured precision, predicted accuracy, and comparisons with correlative measurements made in a series of balloon underflights. All balloon measurements used for comparisons were made using the solar occultation technique and, since NO_2 varies significantly over the diurnal cycle, a photochemical model was used to time translate the data to the LIMS time. Because of this, the comparisons were primarily qualitative. Features such as profile shape and slope of the mixing ratio altitude distribution are in good agreement. The mean difference between LIMS results and the balloon data is well within the range of the sum of the error bars for the two data sets. Comparisons are also made with past balloon measurements taken in the 40°N to 50°N latitude band and with photochemical model predictions of the vertical profile. The LIMS data fall within the range of previous mixing ratio measurements and they are consistent with model estimates. The calculated on-orbit precision is 0.3 ppbv and the estimated accuracy from simulations is ~2 ppbv over the 3 mb to 10 mb range. Accuracy degrades at higher and lower pressure levels. These results provide the first day-night set of NO_2 measurements from space.
J. Geophys. Res., Green, Paper 3C1456

1410 Chemistry of the atmosphere
A MODEL STUDY OF THE EFFECTS OF INTERMITTENT LOSS ON ODD NITROGEN CONCENTRATIONS IN THE LOWER TROPOSPHERE
R. W. Stewart (NASA/Goddard Space Flight Center, Atmospheric Chemistry Branch, Code 964, Greenbelt, Maryland, 20771), S. Hameed and C. Matloff
We have developed a time-dependent box model of the lower troposphere which includes a description of photochemical and physical processes. This model has been applied to the calculation of nitric acid and NO_x ($NO+NO_2$) concentrations over a diurnal cycle which includes precipitation. Nitric acid concentrations and the HNO_3/NO_x ratio are found to be highly variable under the assumptions regarding the frequency, duration, and intensity of precipitation employed in this model. The chemistry of odd nitrogen compounds during the night is potentially important in establishing the level of nitric acid in the lower troposphere. These calculations also indicate that relatively large (factor of two) errors may occur when the continuity equation describing nitric acid variations is averaged over a diurnal cycle which includes precipitation. Interpretation of simultaneous measurements of HNO_3 and NO_x will require some knowledge of the history of the observed air mass and may require an improved understanding of nighttime odd nitrogen chemistry. (Heterogeneous loss, odd nitrogen).
J. Geophys. Res., Green, Paper 3C1595

1420 (Chemistry of Meteorites and Tektites)
THERMAL METAMORPHISM OF Si_2O_3 (CIRCUMSTELLAR DUST ANALOG)
J. A. Nuth and B. Donn (Code 691, NASA/GSFC, Greenbelt, MD 20771)
We have experimentally studied the thermal behavior of Si_2O_3, the metastable condensate from SiO vapor. Si_2O_3 and its successor, amorphous quartz, have previously been shown to have infrared spectral features similar to some which appear in the spectra of grains in oxygen-rich circumstellar regions. Thermal annealing experiments show that only one Si_2O_3 decay process operates over the range 750K < T < 1000K. This process is a unimolecular disproportionation reaction. The rate of this transformation can be expressed as $k(hr^{-1}) = 10^{7}$ exp(-80kcal/mole/RT). Using this rate constant we find that a significant fraction of freshly nucleated circumstellar grains can survive passage through a typical circumstellar shell virtually unaltered in structure. We emphasize that this is only the first in a series of laboratory experiments intended to study the metamorphism of newly condensed circumstellar material ejected into the interstellar medium. Grains similar to those might have been incorporated into the primitive solar nebula provided that they could also survive passage through the general interstellar medium. (Interplanetary Dust, Interstellar Grains, Circumstellar Material).
J. Geophys. Res., Red, Paper 3B5030

1440 Chemistry of the Solid Earth
STILLWATER ANORTHOSITES: A LUNAR ANALOG?
P.A. Salpas (Department of Earth and Planetary Sciences and McDonnell Center for the Space Sciences, Washington University, St. Louis, Missouri 63130), L.A. Haskin and I.S. McCallum
Samples of anorthosite from Stillwater Complex units AN-I and AN-II were analyzed by INAA for FeO, CaO, Na_2O, REE, and other trace elements. No compositional trend with stratigraphic position was observed. Mean concentrations for most elements are about the same for three traverses (two for AN-II) but CaO, FeO, and Sr concentrations are slightly different for the three traverses. The elements are not normally or lognormally distributed among samples from a single traverse. Strong interelement correlations can be understood in terms of sample mineralogy. Little evidence for compositional evolution of minerals during precipitation of the entire Middle Banded Zone is apparent. As in lunar anorthosites, the component of trapped residual liquid is relatively insignificant (less than 5%). In addition to plagioclase, which makes up, on average, 90% of the anorthosites, the rocks contain interstitial pyroxene (augite and inverted pigeonite) and, in some cases, quartz, titano-magnetite, sulfides and rare apatite and allanite. There is an inverse relationship between the amounts of pyroxene and quartz. General compositional trends, exemplified by La-Sc systematics indicate that the bulk of the poikilitic pyroxene appears to be cumulus-adcumulus, presumably formed at the crystallization front from a magma saturated in plagioclase and pyroxene. A small fraction of the pyroxene and plagioclase plus all the quartz and other trace minerals formed from the minor trapped liquid component. The irregular distribution of pyroxene oikocrysts indicates that interstitial melt migrated substantially prior to final consolidation of the rock. (Anorthosite, trace elements, trapped liquid).
J. Geophys. Res., Red, Paper 3B5032

1499 General
CHEMISTRY OF THE APOLLO 11 HIGHLAND COMPONENT
J. C. Laul (Radiological Sciences Department, Battelle, Pacific Northwest Laboratories, Richland, Washington, 99352)
Chemical data (28 major, minor and trace elements) were obtained by INAA for 38 hand-picked highland fragments (1-20 mg) from coarse fines 10085. The Apollo 11 highland chemical groups are represented by a range of petrographic types. Six major chemical highland groups are identified in the Apollo 11 fragments. These are 1) high-K KREEP; 2) anorthosite (e.g. 15415, 60015) with 10X chondrite REE abundances and a positive Eu anomaly and anorthosite with 30X chondrite abundances and a positive Eu anomaly; 3) ANT (67075); 4) LKFM (77135); 5) anorthositic gabbro (68415) with a positive Eu anomaly, and 6) Apollo 11 "dominant highland component," 2X-10X chondrite REE abundances with a positive 10X-14X chondrite Eu anomaly. There are three newly recognized groups in the Apollo 11 highland suite, based on the REE patterns. These are: a) ANT with 8X chondrite La, 22X chondrite abundances, and a positive Eu anomaly, b) 10X chondrite flat pattern with 14X chondrite positive Eu anomaly, and c) 2-3X chondrite flat pattern with 10X chondrite positive Eu anomaly. The Apollo 11 highland suite is very low in potassium (non-KREEPy). Overall, the Apollo 11 highland suite is quite similar to the Apollo 16 suite. Most previously recognized highland chemical groups are represented in the Apollo 11 highland component.
J. Geophys. Res., Red, Paper 3B5029

Geomagnetism and Paleomagnetism

1520 Interactions Between Exterior Sources and Interior Properties
THE ELECTRICAL CONDUCTIVITY OF THE UPPER MANTLE AS ESTIMATED FROM SATELLITE MAGNETIC FIELD DATA
Edna M. Didwall (Lawrence Livermore National Laboratory, University of California, Livermore, CA 94550)
The electrical conductivity of the upper mantle is estimated from low latitude magnitude field variations (magnetic storms) caused by large fluctuations in the equatorial ring current. The data base is derived from magnetic field magnitude data measured by satellites Ogo 2, 4, and 6 which offer better global coverage than land-based observatories. The procedures of analysis consist of i) separation of the disturbance field into internal and external parts relative to the surface of the earth, ii) estimation of a response function "Q(ω)" which relates the internally generated magnetic field variations to the external variations due to the ring current, and iii) interpretation of the estimated response function using theoretical response functions for assumed conductivity profiles. Some consideration is given to possible ocean and ionospheric effects. Best estimates of the geomagnetic response function Q(ω) for 0.2 to 2.0 cycles/day indicate an upper mantle conductivity of order 10^{-2} S/m. (Satellite, induction, conductivity, upper mantle).
J. Geophys. Res., Red, Paper 3B1608

2550 Time variations, diurnal to secular
STORM-TIME CHANGES OF GEOMAGNETIC FIELD AT MAGSAT ALTITUDES (325-550 Km) AND THEIR COMPARISON WITH CHANGES AT GROUND LOCATIONS
R. P. Kane (Instituto de Pesquisas Espaciais - INPE, Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq, 12200-São José dos Campos, SP, Brasil), N. B. Trivedi
The values of H, X, Y, Z at MAGSAT altitudes were first expressed as residuals ΔH, ΔX, ΔY, ΔZ after subtracting the model HMD, XMD, YMD, ZMD. The storm-time variations of ΔH showed that ΔH (Dusk) was larger (negative) than ΔH (Dawn) and occurred earlier, indicating a sort of hysteresis effect. Effects at MAGSAT altitudes were roughly the same (10% accuracy) as at ground, indicating that these effects were mostly of magnetospheric origin. The ΔY component also showed large storm-time changes. The latitudinal distribution of storm-time ΔH showed north-south asymmetries varying in nature as the storm progressed. It seems that the central plane of the storm-time magnetospheric ring current undergoes latitudinal meanderings during the course of the storm. (Geomagnetic variations, storm-time changes).
J. Geophys. Res., Blue, Paper 3A1600

Meteorology

3715 Stratospheric perhydroxyl (HO_2) measurement
A MEASUREMENT OF STRATOSPHERIC HO_2 BY GROUND-BASED MM-WAVE SPECTROSCOPY.
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We have measured stratospheric perhydroxyl (HO_2) using a sensitive mm-wave receiver to obtain spectroscopic line profiles of three rotational emission lines in the vicinity of 265.8 GHz. The observations were carried out over four days in September-October 1982 at Mauna Kea, Hawaii (19.5 N latitude) and yield good agreement with the column density and vertical distribution predicted above ~35 km altitude by three representative 2-D photochemical models employing JPL 82-57 reaction rates and chemistry; predictions from the same models using WMO/NASA chemistry yield poor agreement with our observations. Contrasts between current theoretical predictions and previous observations by Anderson, et al. are pointed out for HO_2 in the 28-37 km range, along with the difficulty of joining the latter with our own measurements through a monotonically varying vertical profile for HO_2. A possible explanation involving strong temporal and spatial variation in stratospheric water vapor content is suggested. (Stratospheric chemistry, stratospheric trace gases, HO_2)
J. Geophys. Res., Green, Paper 3C1598

3715 Chemical composition and chemical interactions (Meteorology)
EFFECTS OF HETEROGENEOUS PROCESS ON NO_3, HONO AND HNO_3 CHEMISTRY IN THE TROPOSPHERE
Brian G. Heikes (National Center for Atmospheric Research, Boulder, Colorado, 80307) and Anne M. Thompson
Atmospheric measurements of trace oxides of nitrogen, i.e., NO_3, HONO, and HNO_3, are at variance with accepted photochemical theory. In particular, measured NO_3 levels at night are lower than expected from photochemical equilibrium, observed HONO concentrations increase throughout the night, and HNO_3 or NO_3^- is produced rapidly in cloud and plume.
We investigate theoretically the potential role of wet particles in the chemistry of NO_3, HONO, and HNO_3 through a model that incorporates H-N-O photochemistry and a heterogeneous scavenging parameterization. The model includes effects due to temperature, pressure, photostationary state number, photolysis rate, diffusion rate and sticking coefficient.
Application of the model to suitable NO_3 case studies reveals that low NO_3 concentrations could result from the reaction of NO with NO_3 provided NO is present at night. However, in the absence of NO low NO_3 can result from heterogeneous loss of NO_3 and N_2O_5, provided their sticking coefficients are greater than 10^{-3}.
In the study of HONO we find that a nocturnal production by heterogeneous H_2O reactions is insufficient to account for observed levels of HONO.
Model sensitivity calculations demonstrate that the formation of HNO_3 or NO_3^- in-cloud can occur through two distinct and complementary mechanisms. The route, $OH + NO_2 + HNO_3$, can account for considerable HNO_3 formation in-cloud but only during daylight hours. A heterogeneous mechanism consisting of NO_3 and N_2O_5 absorption and reaction on droplets is shown to be a viable source of HNO_3 in-cloud during all hours.
J. Geophys. Res., Green, Paper 3C1439

3715 Chemical composition and chemical interactions
THE ATMOSPHERIC CHEMISTRY OF HYDROGEN CYANIDE (HCN)
R. J. Cicerone (National Center for Atmospheric Research*, P.O. Box 3000, Boulder, CO 80307) and R. Zellner
Since 1981, three groups have reported spectroscopic detections and measurements of hydrogen cyanide in the atmosphere. HCN concentrations (volume mixing ratios) of (1.5-1.7) x 10^{-10} appear to characterize the stratosphere and the northern hemisphere's nonurban troposphere. In this paper, we explore the atmospheric behavior of HCN by examining its chemical and photochemical properties. Its principal sinks are reactions with atmospheric OH and $O(^1D)$; precipitation appears to be a negligible sink. In the stratosphere vacuum UV photons also attack HCN. Atmospheric model calculations show that HCN should be relatively well mixed in the troposphere and that its concentration decreases slowly with altitude in the stratosphere. Its atmospheric residence time appears to be about 2.5 years, although 1-5 years is a possible range. To maintain the observed atmospheric burden of HCN, an annual source of about 2 x 10^{11} g nitrogen as HCN is required; we speculate as to the identity of these sources. Oxidation of HCN by OH, while the major sink for atmospheric HCN, is not simple or direct. Instead, oxidation proceeds from the HCN-OH adduct formed in HCN + OH reactions. These pathways and their uncertainties are outlined here.
*The National Center for Atmospheric Research is sponsored by the National Science Foundation.
J. Geophys. Res., Green, Paper 3C1570

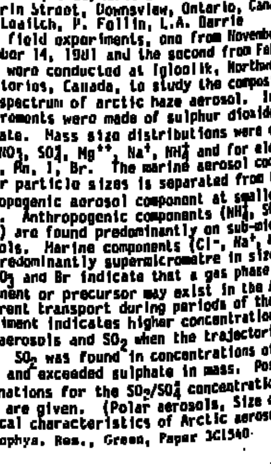
3720 Climatology (Sensitivity to CO_2 Increase)
INFLUENCE OF OCEANIC HEAT TRANSPORT UPON THE SENSITIVITY OF A MODEL CLIMATE
M. J. Spelman and S. Manabe (Geophysical Fluid Dynamics Laboratory/NOAA, Princeton University, P.O. Box 308, Princeton, New Jersey 08540)
The influence of oceanic heat transport on the sensitivity of climate to an increase of the atmospheric CO_2 concentration is studied. For this purpose, the CO_2-induced changes of two mathematical models with and without the effect of ocean currents are compared. The first model is a general circulation model of the coupled ocean-atmosphere system which includes ocean currents. In the second model the oceanic component of the first model is replaced by a simple mixed layer without ocean currents. Both models have limited computational domain with idealized geography and annual mean insolation. For each model, the sensitivity of climate is evaluated from the difference between the equilibrium climates of the normal CO_2 and four times the normal CO_2 concentrations. The sensitivities of the two models are compared in order to investigate the influence of oceanic heat transport on climate sensitivity. The results indicate that the presence of ocean currents reduces the sensitivity of surface air temperature because of the difference in magnitude of the surface albedo feedback effect. The poleward transport of heat by ocean currents raises the surface temperature at high latitudes, shifts poleward the margins of snow and sea ice, decreases the contribution of the albedo feedback effect and reduces the sensitivity of climate. The equilibrium response of climate is compared with the transient response of climate to a sudden increase of atmospheric CO_2 content. According to this comparison, the latitudinal dependence of the equilibrium response of zonally averaged surface temperature is qualitatively similar to the transient response approximately 25 years after the time of the sudden CO_2 increase. This result suggests that the distribution of the zonally averaged temperature change in response to a gradual increase of atmospheric carbon dioxide also resembles the distribution of the equilibrium response provided that the characteristic time scale of the CO_2 increase is longer than 25 years. (Climate sensitivity, numerical model, oceanic heat transport).
J. Geophys. Res., Green, Paper 3C1287

3736 Electrical phenomena
AMBIPOLAR DIFFUSION IN THE MIDDLE ATMOSPHERE
I. Tzur and R. Roble (National Center for Atmospheric Research*, Boulder, CO 80307)
In the middle atmosphere above 60 km the electron concentration increases with altitude, reaching values of 10^{11} m^{-3} in the daytime ionospheric E-region near 100 km. The electrons are more mobile than the ions, and diffuse more rapidly through the neutral atmosphere. The electron diffusion polarizes the medium, causing an electric field to develop that acts to retard the electron diffusion and enhance the conduction current of ions. We use a global zonally averaged numerical model of atmospheric electricity from the ground to 100 km to examine the effect of ambipolar diffusion and the earth's geomagnetic field on the currents and fields in the middle atmosphere. The results show that above about 65 km ambipolar diffusion generates local electric fields and conduction currents that balance electron diffusion currents. The electric fields and conduction currents are a few orders of magnitude larger than the vertical fields and currents calculated from the downward mapping of the ionospheric potential without taking electron diffusion into account. Ambipolar diffusion does not alter the total current flowing in the global circuit. It is a local effect where enhanced conduction currents flow to balance the electron diffusion current.
*The National Center for Atmospheric Research is sponsored by the National Science Foundation.
J. Geophys. Res., Blue, Paper 3A1465

3735 Electrical Phenomena
COMMENTS ON MEASUREMENT OF THE GLOBAL ELECTRICAL CIRCUIT AND THE HY-WIRE POTENTIAL VARIATIONS AT WALLOPS ISLAND
R. Markson (Center for Space Research, 37-241, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139)
This paper discusses the problem of how meteorological processes in the lower atmosphere control the variation of atmospheric potential with altitude. This prevents observation of the global circuit variation in regions with convection, pollution and mesoscale wind effects such as the sea breeze. Analysis of "Hy-wire" tethered balloon potential measurements by Holzworth (1983) indicates that increases and decreases occurred coincident with meteorological variations that would be expected to alter local electric field intensity. When the curve determined by the hourly UT variation of the global circuit (as represented by the Carnegie curve) is compared with the hourly average of the tethered balloon potentials there is no correlation. For the abrupt drops in potential (which occurred coincident with the breakup of fog or discontinuation of the morning rise in temperature) to be due to changes in the global circuit would require more than 50% of the several thousand global thunderstorms to stop abruptly--this is unlikely. Fog and convection of hazy air rich in space charge make the Wallops Island coastal region inappropriate for attempts to measure the global circuit variation. The excessive Hy-wire voltages suggest a possible problem with this measuring technique; potentials at 530 m were 48% higher than comparable aircraft measurements. Extrapolated to the ionosphere, the tethered balloon potential profiles would give ionospheric potentials on the order of 500 kV which is well beyond values measured in other programs. (Ionospheric potential, global circuit, atmospheric electric fields).
J. Geophys. Res., Green, Paper 3C1634

3743 Gravity waves, tides, and compressional waves
SIMPLIFIED DERIVATION OF AN ALGORITHM FOR NONLINEAR GRAVITY WAVES
J. Weinstock (National Oceanic and Atmospheric Administration, Aeronomy Laboratory, Boulder, CO 80303)
A simplified proof is given that the linear dispersion relation for gravity waves is converted into a nonlinear relation by making the replacement $|\omega_k - k\cdot u_0|$ → $|\omega_k - k\cdot u_0 - i d_k|$, where ω_k is the wave frequency, k is the wavevector, u_0 is the mean flow, and d_k is a nonlinear damping rate explicitly determined by the wave velocity. This derivation differs from a previous one in its brevity as well as relative simplicity. The purpose is to present a derivation that does not require previous familiarity with the statistical theory of strong nonlinear interactions, and to more explicitly reveal the underlying assumptions and approximations. A difference of substance, is that a spacetime average is used instead of an ensemble average and the theory is no longer restricted to random phased waves. The physical significance of d_k is then elucidated and related to recent experimental observations. Limitations of the derivation are to a quasi-stationary, homogeneous state in which u_0 and other average quantities vary slowly, to wave lengths satisfying $2k_z H >> 1$, and to wave amplitudes that are too large to be treated by weak mode-coupling theories.
J. Geophys. Res., Blue, Paper 3A1367

3770 Particles and Aerosols (Arctic Haze)
MASS SIZE DISTRIBUTION OF CHEMICAL CONSTITUENTS OF THE WINTER ARCTIC AEROSOL
R.M. Hoff (Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4), W.R. Leaitch, P. Fellin, L.A. Barrie
Two field experiments, one from November 24 - December 14, 1981 and the second from February 19-27, 1982, were conducted at Igloolik, Northwest Territories, Canada, to study the composition and mass size spectrum of arctic haze aerosol. In addition, measurements were made of sulphur dioxide and sulphate. Mass size distributions were obtained for Cl^-, NO_3^-, $SO_4^=$, Mg^{++}, Na^+, NH_4^+ and for elements Cl, Na, V, Mn, I, Br. The marine aerosol component at larger particle sizes is separated from the anthropogenic aerosol component at smaller particle sizes. Anthropogenic components (NH_4^+, $SO_4^=$, V, Mn) are found predominantly on sub-micrometre aerosols. Marine components (Cl^-, Na^+, Mg^{++}) are predominantly supermicrometre in size. Results for NO_3^- and Br indicate that a gas phase component or precursor may exist in the Arctic. Different transport during periods of the February experiment indicates higher concentrations for the haze aerosols and SO_2 when the trajectories are from Asia. SO_2 was found in concentrations of 0.3 - 4.3 $\mu g/m^3$ and exceeded sulphate in mass. Possible explanations for the $SO_2/SO_4^=$ concentration ratio are given. (Polar aerosols, Size distributions, Chemical characteristics of Arctic aerosols).
J. Geophys. Res., Green, Paper 3C1540



Mineralogy, Petrology, and Crystal Chemistry

4230 Experimental mineralogy and petrology
SHOCK EXPERIMENTS ON FELDSPAR CRYSTALS
R. Ostertag (Institut für Mineralogie, Corrensstrasse 24 D-4400 Münster, W-Germany)
Single crystals of sanidine, orthoclase, microcline, oligoclase, and labradorite as well as polycrystalline bytownite were shocked from 10.5 to 45 GPa and recovered. The direction of shock wave propagation was always parallel to the crystallographic a-axis. Optical observations reveal a continuous sequence of shock effects: fracturing starts to develop at < 10.5 GPa, planar elements develop at 10.5-14 GPa, mosaicism at 18-28 GPa, transformation of the crystals into diaplectic glass begins at 26-34 GPa, and formation of melt glass is indicated at > 42 GPa. Microcline, however, remains weakly birefringent even at 45 GPa. Refractive indices of diaplectic glass drop sharply at shock pressures between 30 and 40 GPa. Xray investigations reveal only a minor expansion of the unit cell of sanidine, whereas the other feldspars display no systematic change of lattice constants. The structural state (Al,Si-distribution) of feldspars is not affected by shock. EPR analyses display the disordering of the crystal structure and the formation of a short-range order phase in feldspars at pressures as low as 10.5-14 GPa. The beginning of the formation of diaplectic glass in the range of 18-22 GPa is evident from IR-spectra of shocked feldspars. It is assumed that diaplectic glass is an arrangement of grossly unchanged crystalline material and a glassy phase that is structurally indistinguishable from fusion-formed glass. The influence of the chemical composition and initial structural state of feldspars on the development of shock features is believed to be less than the influence of exsolution lamellae and alteration products. Based on the results of these investigations, pressure ranges are given for the lower and upper boundary of the mixed-phase regime of the pV Hugoniot (p = shock pressure; V = specific volume) for all samples. Two independent methods for the determination of shock pressures from residual shock effects are proposed based on optical and IR-spectroscopic analyses. (Shock experiments, shock effects, diaplectic glass, feldspars).
J. Geophys. Res., Red, Paper 3B5112

[illegible]260 Petrography and Petrogenesis
PETROLOGY OF HIGH-MG DIKES FROM THE BEARTOOTH MOUNTAINS, MONTANA: A SEARCH FOR THE PARENT MAGMA OF THE STILLWATER COMPLEX
J. Longhi (Dept. of Geology & Geophysics, Yale Univ., New Haven, CT 06511), J. L. Wooden and K.D. Coppinger
Six geochemically distinct groups of Precambrian high-Mg dikes have been examined to determine if any could have been a sample of or closely related to the parent magma of the Stillwater Complex. Only two groups have sufficiently magnesian olivine and orthopyroxene, but neither of these has sufficiently calcic plagioclase. In terms of major elements there appear to be only two distinct magma types: one has a high orthopyroxene component and is petrographically similar to noritic dikes and sills near the Great Dyke of Zimbabwe and the Bushveld Complex of South Africa; the second is similar to primitive tholeiites with higher plagioclase and diopside components than the first. All of the groups are enriched in light-REE and have unusually high K_2O concentrations. Model calculations indicate that crustal contamination (30-50%) of fractionating komatiitic magmas is consistent with the major and trace element characteristics of the first magma type. Less extensive contamination of komatiitic magmas may produce the parental magmas of the large layered intrusions.
J. Geophys. Res., Red, Paper 3B5053

Oceanography

4505 Boundary Layer and Exchange Processes
A MODEL OF INTERFACIAL GAS TRANSFER FOR A WELL-ROUGHENED SEA
S.R. Kerman, Boundary-Layer Research Division, Air Quality and Inter-Environmental Research Branch, Atmospheric Environment Service, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4
A model is presented for the flux of a non-reactive gas through the air-sea interface characterized by patches of breaking waves. A jet of entrained air bubbles resulting from a sufficiently large convergence of the surface drift current is visualized as the physical mechanism associated with the gas transfer. The development is based on the work of Yaglom and Kader for rough wall transfer of heat and momentum and is applied here to a compliant rather than a solid surface. An extension of the Charnock relationship for surface roughness is provided to account for contributions to surface root mean square elevation from a band of wavenumbers, centred about the the minimum phase velocity of short gravity-capillary waves, which are hypothesized to support most of the wind stress. The transfer is considered to occur only in regions of active breaking not necessarily visible, which, although occupying a small percentage of the total surface area, are quite sensitive to wind effects. Comparison with data confirms the general validity of the model, but the scatter and limited representativeness of various data sets preclude a more definitive testing of the model.
J. Geophys. Res., Green, Paper 3C1375

4505 Boundary layer and exchange processes
TURBULENT CURRENT MEASUREMENTS IN A WIND-WAVE TANK
J.-T. Lin and M. Gad-el-Hak (Flow Research Company, Kent, Washington, 98032)
Laboratory experiments were conducted in a wind-wave tank to study the turbulence characteristics in the air and water boundary-layers generated by wind and waves. The turbulent air boundary-layer over the water surface was surveyed using two hot-wire probes. It was found to be a good simulation of an atmospheric boundary layer over a body of water. Capacitance probes were used to record the wave height. Spectra, wave phase velocity, dominant wavelength and frequency, and other statistics of the wind-waves were computed. The water boundary layer below the water surface was surveyed using an array of ten cross-element hot-film probes to measure the streamwise and vertical components of velocity. Various turbulence statistics including mean velocity, root-mean-square velocity fluctuations, Reynolds stress, dissipation rate, spectra, and higher order statistics were computed. Similarity profiles were found for the mean subsurface current and the RMS turbulent fluctuations in the streamwise and vertical directions. The velocity spectra indicated the relative importance of the wave-induced motion, which attenuated exponentially with depth. (Wind-wave tank, current, similarity profiles, boundary layer).
J. Geophys. Res., Green, Paper 3C1376

4599 General (Upwelling)
THE NIMBUS-7 CZCS EXPERIMENT IN THE BENGUELA CURRENT REGION OFF SOUTHERN AFRICA, FEBRUARY 1980. PART 2: INTERPRETATION OF IMAGERY AND OCEANOGRAPHIC IMPLICATIONS
L. V. Shannon (Sea Fisheries Research Institute, Private Bag X2, Rogge Bay 8012, Cape Town, South Africa), P. Schlittenhardt and S. A. Mostert
Three Nimbus-7 CZCS chlorophyll images of the southern Benguela Current region off the west coast of South Africa on 9, 13 and 15 February 1980 during a surface truth experiment in the area are evaluated in the light of a time series of airborne radiation thermometry and wind data for this period, and the validity of CZCS chlorophyll estimates for the region is discussed. There was good agreement between upwelling and relaxation in the system and changes in the distribution of chlorophyll. The development of upwelling tongues with the subsequent increase in chlorophyll concentrations and the intensification of the oceanic front off Cape was evident. A 'S'-shaped band of high chlorophyll was present well off-shore of the Orange River mouth and lends support to the existence of a divergence zone at the shelf break in the area; there being fair agreement between satellite buoy tracks, topography and the position of the oceanic colour front. Areas of elevated chlorophyll were evident in two bays on the south coast on 13 February 1980 and these are ascribed to an earlier upwelling event in the region. Implications for future work in the area are discussed. (Benguela, upwelling, chlorophyll, ocean colour).
J. Geophys. Res., Green, Paper 3C1541

Particles and Fields—Interplanetary Space

5520 Cosmogenic effects
^{53}Mn PROFILES IN FOUR APOLLO SURFACE CORES
K. Nishiizumi (Department of Chemistry, B-017 University of California, San Diego, La Jolla, California 92093), M. T. Murrell and J. R. Arnold
^{53}Mn data are presented for four Apollo cores with an emphasis on the past 10^7-year history of these samples. (1) Core 15011 has excess ^{53}Mn down to a depth of at least 9 cm, which is probably due to the continuous addition of near-surface irradiated material. High ^{53}Mn was also observed at 17 cm, which suggests that this might have been the surface at this site, 7-10 m.y. ago. The soil found covering the 15011 core tube keeper appears to be surface soil, but most likely not from the top of 15011. (2) The ^{53}Mn profile for 64002 above 12 cm is relatively flat and in excess of that calculated for a static core, which suggests that the upper part of this core was deposited rapidly about 2 m.y. ago. As this soil appears to be mature, well irradiated local material, it seems unlikely that it is ejecta from South Ray crater unless South Ray crater is much older than 2 m.y. (3) Results for the Apollo 17 drill stem show a large excess of ^{53}Mn from at least 3 cm downwards. Some magnetic separates obtained from this core have very high ^{53}Mn activities, probably due to the presence of agglutinates that were recently irradiated very near the surface. These results are consistent with the suggestion of the Battelle-Northwest group that this core sampled a young crater that had partially filled due to the slumping of surface irradiated material. (4) The ^{53}Mn content of the upper part of 74002 is similar to that of trench samples collected nearby and indicates that the gray, orange, and black soils at this site have been exposed together near the surface for at least the last 10 m.y. (Cosmogenic nuclides, galactic cosmic ray, solar cosmic ray)
J. Geophys. Res., Red, Paper 3B5028

Particles and Fields—Ionosphere

5510 Auroral zone magnetic effects
HEMISPHERICAL JOULE HEATING AND THE AE INDICES
W. Baumjohann (Max-Planck-Institut für extraterrestrische Physik, 8046 Garching, W-Germany) and Y. Kamide
A linear regression analysis of Joule energy deposition rates integrated over the northern hemisphere as a function of the standard auroral electrojet indices yields a correlation coefficient of r = 0.7 - 0.9. Except for very disturbed times, when the AE(12) index tends to underestimate the electrojet current, the hemispherical Joule heating rate can be calculated by substituting 1 nT in the AE index by approximately 0.3 GW. This scale factor is appreciably larger than those employed in earlier energy coupling studies. A higher scale factor is found for the regression between Joule heating caused by eastward current versus AU than for that caused by the westward electrojet versus AL. This is consistent with typically lower ionospheric conductivity values in the eastward electrojet region which require higher electric fields and thus more Joule heating for a given eastward current or AU value than for the same intensity of the westward electrojet. (Auroral zone magnetic effects, high-latitude ionospheric currents, Joule heating).
J. Geophys. Res., Blue, Paper 3A1542

5515 Aurora
AURORAL PHOTOMETRY FROM THE ATMOSPHERE EXPLORER SATELLITE
M. H. Rees (Geophysical Institute, University of Alaska, Fairbanks, Alaska, 99701) and V. J. Abreu (Space Physics Research Laboratory, University of Michigan, Ann Arbor, Michigan, 48109)
Two passes of the Atmosphere Explorer-C satellite over the Poker Flat Optical Observatory and the Chatanika Radar facility provided the best auroral measurements from space and from the ground available to date for demonstrating the capability of remote sensing from space to yield quantitative auroral and ionospheric parameters. It is shown that the emission rate of the N_2^+ (1NG) 4278Å band computed from intensity measurements of energetic auroral electrons tracks the same spectral feature measured remotely from the satellite over two decades of intensity. This provides a stringent test for the procedure adopted to correct the optical measurements for atmospheric scattering effects and verifies the absolute intensity with respect to the ground-based photometric measurements, referenced to a laboratory calibration. In situ satellite measurements of ion densities and ground-based radar measurements of electron density profiles provide a consistent picture of the ionospheric response to the auroral input that our model is capable of predicting while at the same time also predicting the observed optical emission rate. Modeling, therefore is the link between global remote sensing optical measurements and the ionospheric response to auroral energetic particle bombardment.
J. Geophys. Res., Blue, Paper 3A1487

5530 High-latitude ionospheric currents
ION CYCLOTRON WAVES AS A POSSIBLE SOURCE OF RESONANT AURORAL RADAR ECHOES
B. G. Fejer (School of Electrical Engineering, Cornell University, Ithaca, New York, 14853), R. W. Reed, D. T. Farley, W. E. Swartz and M. C. Kelley
Auroral backscatter radar observations were made from Ithaca, New York at 50 MHz during the early morning of April 1, 1976, a period of high magnetic disturbance (K_p ~ 8). The backscattered power showed large, rapid (time scale of a few minutes or less) variations, characteristic of discrete radar aurora, from L=3.5-4. Doppler spectra of waves propagating in nearly the north-south direction from up to 28 different ranges were obtained simultaneously with good spatial (7.5 km) and temporal (2 s) resolution. Some unusual spectra with very narrow peaks at Doppler shifts between about 70 and 90 Hz were observed and were apparently associated with sheared flows of the auroral plasma. These echoes were observed at the southern edge of the scattering region, which moved poleward with a velocity which sometimes exceeded 800 m/s. There is evidence that the echoes were generated above about 140 km. Present electrojet instability theories cannot explain these narrow spectra, but the Doppler shift suggests that they might be caused by ion cyclotron waves generated by field aligned currents (electron drifts). However, the excitation of ion cyclotron waves requires currents considerably stronger than typically quoted mean values (~10^{-5} $\mu A/m^2$). Furthermore, the most easily excited ion cyclotron waves have wavelengths longer than 3 m and do not propagate in quite the right direction for detection by our radar. The threshold for the waves that we observed is considerably higher than the minimum. Intense localized currents, such as those known to be associated with auroral curls and vortices, (J ≳ 10^{-4} $\mu A/m^2$) appear to be sufficient to excite the longer (~10-20 m) ion cyclotron waves in the upper E region; whether or not the field aligned electron drifts are ever large enough to excite directly the 3 m waves we observe is an open question, but there is at least some evidence which suggests that such drifts do exist in very localized regions during highly disturbed conditions. (Aurora, plasma waves).
J. Geophys. Res., Blue, Paper 3A1535

5530 Latitudinal profile
LATITUDINAL PROFILE OF THE MAGNETOSPHERIC CONVECTION ELECTRIC FIELD AT IONOSPHERIC ALTITUDES FROM A CHAIN OF MAGNETIC AND RADAR DATA.
C. Mazaudier and M. Blanc (CRPE/CNET, 38-40 Avenue du Général Leclerc, 92131, Issy-les-Moulineaux), E. Nielsen and Min-Yun Zi
In this paper a combination of magnetic records with coherent and incoherent radar data at auroral and middle latitudes (STARE and SAINT-SANTIN) allows a quantitative analysis of the latitudinal profile of the convection electric field.
The latitudinal profile is compared with the predictions of the semi-analytical convection model of Senior and Blanc.
The auroral conductivities used in this model are deduced from comparison of the STARE electric field and the magnetic disturbance. Once this normalization is performed, a good agreement is found between the experimental and theoretical electric field profiles.
J. Geophys. Res., Blue, Paper 3A1550

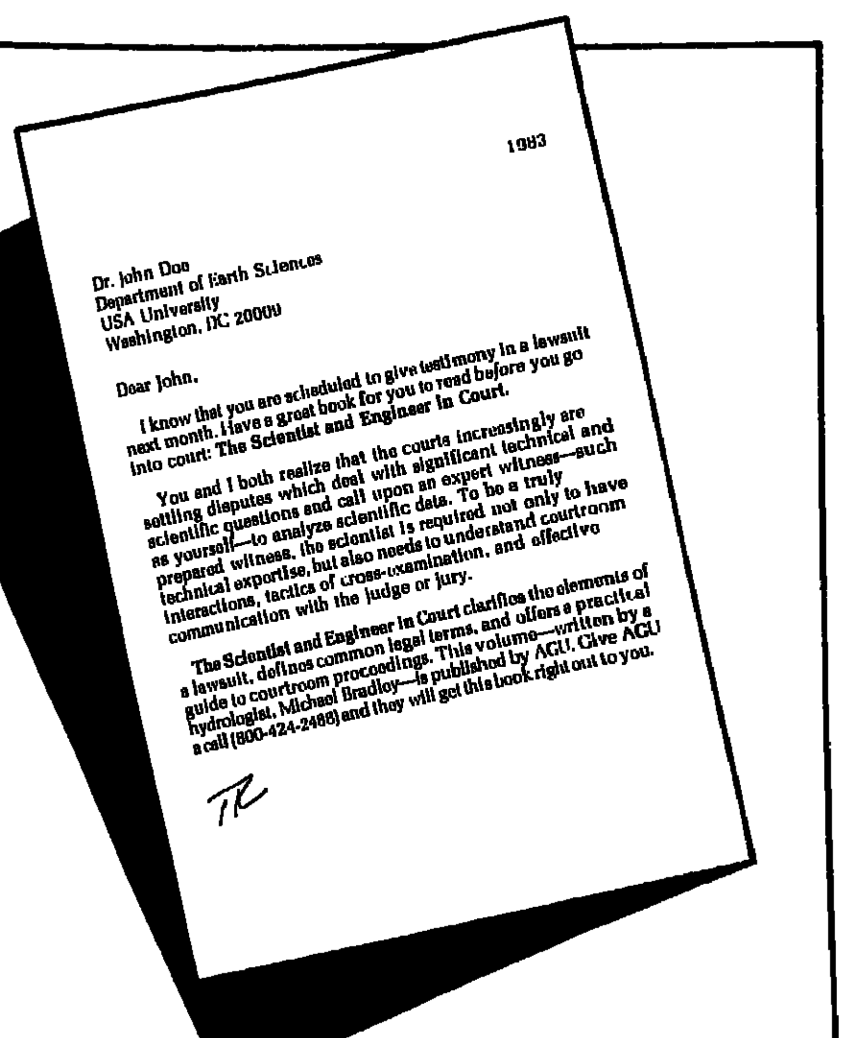
5530 High-latitude ionospheric currents
ELECTRIC FIELD AND PLASMA DENSITY MEASUREMENTS IN THE AURORAL ELECTROJET
R. F. Pfaff (School of Electrical Engineering, Cornell University, Ithaca, New York, 14853), M. C. Kelley, B. G. Fejer, E. Kudeki, C. W. Carlson, A. Pedersen and B. Häusler
Intense electrostatic waves in the auroral E-region have been detected simultaneously on two payloads launched in a mother-daughter configuration from Kiruna, Sweden. The data sets comprise electric field and density measurements from the ambient (DC) conditions to fluctuations as high as 50 kHz. The DC electric field measured by both payloads was 54 mV/m northwest, which corresponded to an electron drift velocity of 1080 m/sec. This electric field drove two-stream waves perpendicular to both B and E observed by both spacecraft throughout an altitude region which agrees quite well with the range predicted by linear two-stream theory. The power in the waves depended on the electron density gradient, diminishing near 107 km where the gradient changed direction for a few kilometers. This observation is consistent with a gradient drift wave contribution to the instability process since the auroral zone geometry does permit a component of the electric field perpendicular to B to be parallel to the vertical electron density gradient. Electric field spectra corroborate these results as a strong component was detected at longer wavelengths (several hundred meters), the spectral regime associated with this instability. The spectra measured on both payloads also reveal an enhanced nearly coherent wave of a few meters wavelength at the topside of the layer (120 km) which also appears as electrostatic and parallel to the current. This spectral feature may be the consequence of a narrow range of wavelengths excited near the two-stream instability threshold. Descending through the layer, the fluctuations fill out to a breadband, turbulent spectrum, extending to scale sizes down to the order of centimeters. Long wavelength waves form the strongest spectral component below 105 km. Power observed perpendicular to the direction of the current indicates the presence of secondary plasma waves. (Plasma instabilities, electrojet, wave measurements).
J. Geophys. Res., Blue, Paper 3A1593

5530 High-latitude ionospheric currents
BRIEF REPORT - AURORA AND ELECTROJET CONFIGURATION IN THE EARLY MORNING SECTOR
Y. Kamide (Kyoto Sangyo University, Kyoto 603, Japan), R. M. Robinson, S.-I. Akasofu and T. A. Potemra
Nearly simultaneous data from the Chatanika radar, the Triad satellite, and the IMS Alaska meridian chain of magnetic and auroral observatories are utilized to examine the spatial relationship among auroras, field-aligned currents, ionospheric electric fields and conductivities in the westward electrojet in early morning hours. The westward electrojet is found to be dominated by one of two different quantities, depending on latitudinal locations in this local time sector. The poleward half of the electrojet is governed by a relatively intense southward electric field. On the other hand, the Hall conductivity is the dominant factor in controlling the electrojet current in the equatorward half. The electrojet center appears to be located within the region of the upward field-aligned current. Major auroral activity is present only in the equatorward half of the electrojet in which the upward field-aligned current prevails, although it appears that the latitudinal variations of the conductivity and current intensity are not well related within that region. (Auroras, auroral zone magnetic effects, magnetic storms.)
J. Geophys. Res., Blue, Paper 3A1520

5530 High-latitudes ionospheric currents
LATITUDINAL VARIATIONS OF JOULE HEATING DUE TO THE AURORAL ELECTROJETS.
M-L Duboin (CRPE/CNET, 38-40 rue du Général Leclerc, 92131 Issy les Moulineaux), Y. Kamide.
Empirical scaling factors between the height-integrated Joule heating rate deduced from measurements of the Chatanika incoherent scatter radar and the square of magnetic perturbations at College are derived. These relationships, calculated for different situations (the eastward and westward electrojets and daytime), are then use to estimate the Joule heating rate along the latitudinal extent of the auroral oval on the basis of magnetometer data from the IMS Alaska meridian chain of observatories. The total heat input for a disturbed day (April 12, 1978) is estimated to be 2.8 10^{17} Joules. (Joule heating, auroral oval).
J. Geophys. Res., Blue, Paper 3A1626

5535 Interaction between waves and particles
THE NONLINEAR GYRORESONANCE INTERACTION BETWEEN ENERGETIC ELECTRONS AND COHERENT VLF WAVES PROPAGATING AT AN ARBITRARY ANGLE WITH RESPECT TO THE EARTH'S MAGNETIC FIELD
T. F. Bell (Space, Telecommunications and Radioscience Laboratory, Stanford University, Stanford, California, 94305)
A theory is presented of the nonlinear gyroresonance interaction in the magnetosphere between energetic electrons and coherent VLF waves propagating at an arbitrary angle ψ with respect to the earth's magnetic field B_0. In particular, we examine the phase trapping (PT) mechanism possibly responsible for the generation of VLF emissions, which involves the phase γ between the right-hand circularly polarized component of the wave magnetic field perpendicular to B_0 and the component of the energetic particle velocity vector perpendicular to B_0. This model is an extension of one developed in earlier work [Bell, 1965; Dysthe, 1971; Nunn, 1974] involving the special case in which ψ = 0. The extended theory predicts that for any finite value of ψ there is a range of resonant particle pitch angle, α, for which γ is not bounded within the range 0 ≤ |γ| < π, and thus PT in the usual sense is not possible. However, PT in an average sense can still exist and long term energy transfer between the gyroresonant electrons and the wave can still take place. For given values of ψ and wave frequency, the trapping frequency ω_t has a countably infinite set of zeros when plotted as a function of α. Regions between zeros alternate between regions of normal PT and regions of anomalous PT in which average phase angle differs by ~180° from the average phase of the normal phase trapped electrons. However, the stimulated radiation from the two groups of particles tends to add in phase. Resonant particles for which ω_t = 0 are not phase trapped. Near the geomagnetic equatorial plane, the wave amplitude necessary to produce PT is directly proportional to the gradient of ψ along B_0. A simple model predicts threshold values greater than 10my for ψ > 37°. For interactions far from the magnetic equator, ψ variations appear to be less important than gradients in B_0. The wave electric field parallel to B_0 generally enhances the strength of the PT process and tends to dominate the process for moderate to high ψ at midfrequency. It is concluded that near the magnetic equatorial plane gradients of ψ may play a very important part in the PT process for nonducted waves. Predictions of a higher threshold value for PT for conducted waves generally agree with experimental data. (Phase trapping, whistler instability, nonducted waves).
J. Geophys. Res., Blue, Paper 3A1943

5535 Interactions between waves and particles
A THEORETICAL MODEL STUDY OF OBSERVED CORRELATIONS BETWEEN WHISTLER MODE WAVES AND ENERGETIC ELECTRON PRECIPITATION EVENTS IN THE MAGNETOSPHERE
H. C. Chang (Space, Telecommunications and Radioscience Laboratory, Stanford University, Stanford, California 94305) and U. S. Inan
A recently extended test-particle computer model of the gyroresonance wave-particle interaction in the magnetosphere is applied to previously reported cases of observed correlations between whistler-mode waves and ionospheric responses to particle precipitation. Three different ionospheric effects, namely X-ray bursts, photoemissions and D-region perturbations, all correlated with VLF waves and believed to be caused by precipitated particles, are considered. The precipitation flux level, pulse shape and the associated time delays are computed for the parameters relevant to each case and are compared with values deduced from the data. The results demonstrate that the existing theoretical model can be useful for interpreting experimental results of this kind. Furthermore, the model results and observations, used together, provide a basis for additional diagnostics of the various parameters of the cold and energetic particle distributions in the magnetosphere. For example, when applied to the observed photoemission case (Helliwell et al., 1980) the model results imply that the trapped energetic particle distribution function at the time could be modeled as proportional to $E^{-n/2}$ with n = 3.5 to 6, where E is the particle energy. (Particle precipitation, ionospheric disturbances).
J. Geophys. Res., Blue, Paper 3A1545



5535 Interactions between waves and particles
CORRELATION OF AURORAL HISS AND UPWARD ELECTRON BEAMS NEAR THE POLAR CUSP
C. S. Lin and J. L. Burch (Department of Space Sciences, Southwest Research Institute, San Antonio, TX, 78284), S. D. Shawhan and D. A. Gurnett.

Simultaneous plasma and wave data obtained by the DE-1 satellite are used to study a correlation between electrostatic auroral hiss emissions at several kHz and upward electron beams at altitudes between 2 and 4 R_E near the dayside polar cusp. Among five randomly selected DE-1 passes, intense electrostatic hiss emissions at frequencies below the electron plasma frequency are found to be associated with strong upward electron beams for every pass. The frequency-time spectrum of auroral hiss near the polar cusp is sometimes characterized by a funnel shape, suggesting that the radiation is emitted from a wave source below the spacecraft. At the center of the enhanced wave region, the electron distribution function above 20 eV is characterized by two components: a hot Maxwellian component and an upward electron beam. The beams generally have a peak energy around 50 eV, a temperature around 20 eV and a density of the order of 1 cm^{-3}. The observed distribution functions are fitted by a drifting Maxwellian function for the electron beam and an isotropic Maxwellian function for the hot component. The empirically fitted plasma parameters are then used to solve the linear dispersion equation of electrostatic waves. The instability analyses indicate that whistler waves propagating with wave normal angles near a small resonance cone can be easily excited by low energy (≤100 eV) upward electron beams. The frequencies of large growth rates are found below the electron plasma frequency, in agreement with the observations. Based on the model that cusp auroral hiss emissions are whistler waves propagating near the resonance cone, ray path studies indicate that the low altitude boundary of the wave source of cusp hiss is located at about 1 R_E. (Auroral hiss, upward electron beam, polar cusp).
J. Geophys. Res., Blue, Paper 3A1549

5545 Ionospheric Disturbances
CALCULATED STORMTIME VARIATIONS IN PLASMASPHERIC THERMAL ION COMPOSITION
K. J. Miller (Laboratory for Planetary Atmospheres, NASA/Goddard Space Flight Center, Greenbelt, MD 20771), H. G. Mayr and I. Harris

Model calculations describing stormtime variations in the earth's dayside plasmasphere are used to examine variations in ion composition. The model storm is initiated by high latitude thermospheric heating which generates meridional winds that carry neutral species, momentum, and energy equatorward. The thermosphere acts on the plasmasphere through collisional transfer of momentum and through chemical reactions between neutral species and ions. Over latitudes near the region of thermospheric heating, the thermosphere-plasmasphere coupling processes cause enhancement in the density of oxygen ions while protons are being lost. Meanwhile, densities of oxygen ions and protons near the equator are increasing together, almost in phase. The largest enhancements in ion density develop at latitudes near 45° invariant for both oxygen and hydrogen. (Ion composition, ion fluxes)
J. Geophys. Res., Blue, Paper 3A1551

5563 Plasma Motion, Convection, Circulation
F-LAYER IONIZATION PATCHES IN THE POLAR CAP
E.J. Weber (Ionospheric Physics Branch, A.F. Geophysics Laboratory, Hanscom AFB, MA 01731), J. Buchau, J.G. Moore, J.R. Sharber, R.C. Livingston, J.D. Winningham, and B.W. Reinisch.

Ground based optical and digital ionosonde measurements were conducted at Thule, Greenland to measure ionospheric structure and dynamics in the nighttime polar cap F layer. These observations showed the existence of large scale (800-1000 km) plasma patches drifting in the anti-sunward direction during a moderately disturbed (Kp ≥ 4) period. Simultaneous Dynamics Explorer (DE-B) Low Altitude Plasma Instrument (LAPI) measurements show that these patches with peak densities of ~ 10^6 el cm^{-3} are not locally produced by structured particle precipitation. The LAPI measurements show a uniform precipitation of polar rain electrons over the polar cap. The combined measurements provide a comprehensive description of patch structure and dynamics. They are produced near or equatorward of the dayside auroral zone, and convect across the polar cap in the anti-sunward direction. Gradients within the large scale, drifting patches are subject to structuring by convective instabilities. UHF scintillation and spaced receiver measurements are used to map the resulting irregularity distribution within the patches. (F-layer, polar cap, ionosphere)
J. Geophys. Res., Blue, Paper 3A1459

5580 Wave Propagation (Propagation through Ionospheric Bubble)
PULSE DISTORTION AFTER PROPAGATING THROUGH AN IONOSPHERIC BUBBLE
R. R. Tucker (Department of Electrical Engineering, University of Illinois at Urbana-Champaign, Urbana, Illinois, 61801), K. C. Yeh

An ionospheric bubble is first modeled based on in situ data measured on board a satellite. The effect such a bubble may have on radio signals propagating through it is next simulated by solving numerically a parabolic equation. Considerable pulse distortion is found. When the computational technique is applied to a frozen but moving bubble, these results imply that the pulse excess arrival time, the pulsewidth and its skewness will fluctuate with time leading to the pulse jitter problem often observed experimentally. (Pulse, propagation, ionospheric bubble, ionospheric scintillation)
Rad. Sci., Paper 3S1537

5599 General (Electron Densities)
POLAR CAP ELECTRON DENSITIES FROM DE-1 PLASMA WAVE OBSERVATIONS
Ann M. Persoon (Dept. of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242), Donald A. Gurnett, and Stanley D. Shawhan

Electric field spectrum measurements from the Plasma Wave Instrument on the Dynamics Explorer-1 spacecraft are used to study the local electron density at high altitudes in the northern polar cap region. The electron density is determined from the upper cutoff of whistler mode radiation at the electron plasma frequency. Median density values over the polar cap at L greater than 10 are found to vary from 35.2 ± 8.5 cm^{-3} at 2.1 R_E to 0.99 ± 0.51 cm^{-3} at 4.66 R_E.

The steady state radial outflow model is examined for consistency with the observed density profile. A power law fit to the radial variation of the electron density yields an exponent of -3.85 ± 0.32, which for the radial outflow model implies a flow velocity increasing nearly linearly with increasing radial distance. Comparison of the observed electron densities with theoretical polar wind densities yields consistent results up to 2.8 R_E. A comparison of the observed electron densities with low-altitude density profiles from the Alouette II and Isis-1 spacecraft illustrate transitions in the slope of the profile at 1.16 R_E and between 1.55 and 2.0 R_E. The changes in the density profile suggest that changes occur in the basic radial transport processes at these altitudes. (Polar cap, density profile).
J. Geophys. Res., Blue, Paper 3A1486

5599 General (Ionospheric Modification)
HF-ENHANCED PLASMA LINES IN THE LOWER IONOSPHERE
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The ionospheric modification facility at Arecibo, Puerto Rico has been used to study Langmuir waves excited in the lower ionosphere by a high-power HF radio wave. Measurements of HF-enhanced plasma lines have been made in the lower F region (<160 km altitude) and in the E region using the 430 MHz radar at Arecibo Observatory. These measurements complement observations made in the past at higher altitudes. Enhanced plasma line spectra observed in the lower F region peak at the so-called "decay line" and contain additional spectral structure similar to that found in the upper F region. In the E region the spectra exhibit narrow peaks located at 430 ± f_{HF}, where f_{HF} is the frequency of the modifying HF wave. While strong plasma line enhancements are commonly observed in sporadic E, only weak enhancements have been detected in the normal daytime E layer. Candidate mechanisms for the E-region enhancements include the oscillating two-stream instability and direct conversion of the HF wave into Langmuir waves. (Ionospheric modification, HF radio wave, E region, Sporadic E).
Rad. Sci., Paper 3S1457

5599 General (Plasma Structuring)
ELECTROMAGNETIC THEORY OF COLLISIONAL INTERCHANGE INSTABILITIES
A. J. Glassman and J. L. Sperling (JAYCOR, P.O. Box 85154, San Diego, California 92138)

Finite parallel wavelength is shown to have a significant effect on the linear growth of instabilities of the Rayleigh-Taylor or E X B gradient drift types. The flute approximation, which explicitly neglects electric fields parallel to the ambient magnetic field, is asymptotically correct for long perpendicular wavelengths, if the parallel component of the electric field is primarily inductive in character. However, when the parallel electric field is primarily electrostatic, there is a profound reduction in the growth rate for long perpendicular wavelengths. This reduction in growth rate arises because parallel electron currents short-circuit the perpendicular electric field driving the instability. Parallel electric fields are more likely to be electrostatic in lower density plasmas than in higher density plasmas. Consequently, the extrapolation of structuring from low density plasmas, such as those found in the spread-F environment, to higher density ionospheric plasmas may not be reasonable.
J. Geophys. Res., Blue, Paper 3A1474

Particles and Fields—Magnetosphere

5720 Interactions between solar wind and magnetosphere
DYNAMIC VARIATION OF THE AURORAL OVAL DURING INTENSE MAGNETIC STORMS
C.-I. Meng (Applied Physics Laboratory, Johns Hopkins University, Laurel, Maryland, 20707)

The latitudinal variations of the noon sector polar cusp region and the nightside auroral oval were examined during three intense geomagnetic storms to investigate the auroral oval dynamics. The variations were compared with the ring current intensity variation (i.e.,) and with changes of the interplanetary magnetic field B_z component to determine the dominant parameter of the large-scale polar region configuration changes during magnetic storms. Deviations of the polar cusp and the midnight auroral oval from their normal quiet time position are also compared to determine the occurrence of the large-scale reconfiguration of the polar region geometry. It is found that: (1) the large (> 10° gm lat) equatorial shift of the auroral oval occurs in coordination with the equatorward motion of the polar cusp region; (2) the polar cusp is displaced by a few degrees more than the nightside auroral oval near the peak of a magnetic storm; (3) the midnight auroral oval recovers more slowly than the polar cusp region during the storm recovery phase, and (4) the midnight oval and the noon sector polar cusp region move coherently with the southward variation of the IMF B_z, but not necessarily with the Dst intensity variations. (Auroral oval, polar cusp, magnetic storm).
J. Geophys. Res., Blue, Paper 3A1521

5755 Plasma instabilities
CHORUS-RELATED ELECTROSTATIC BURSTS AT JUPITER AND SATURN
L. A. Reinleitner (Max-Planck-Institut fur Aeronomie, Postfach 20, D-3411 Katlenburg-Lindau, Germany), W. S. Kurth, and D. A. Gurnett

Analyses of the wideband plasma wave data obtained by Voyagers 1 and 2 at Jupiter and Saturn have revealed electrostatic bursts similar to those recently discovered at Earth in association with whistler-mode chorus. In all three magnetospheres the bursts are characterized by sporadic emissions near or slightly below the electron plasma frequency with bandwidths ranging from 10% to more than 50% of the center frequency. The events found at Jupiter occur in the middle magnetosphere during both the dayside as well as the early morning passes. At Saturn, the bursts occurred in the outer regions of the magnetosphere during the dayside pass. In each of the events analyzed, evidence exists for modulation of the electrostatic bursts by a low frequency wave, presumably chorus. One of the observations gained at Jupiter includes the detection of a low-frequency band at the proper frequency for chorus. Detailed waveform analysis confirms that this band does, indeed, modulate the electrostatic bursts. Based on the present understanding of the terrestrial observations it is believed that the electrostatic bursts are generated by an electron beam trapped in Landau resonance with the chorus. (Electrostatic bursts, chorus, Jupiter, Saturn).
J. Geophys. Res., Blue, Paper 3A1553

5755 Plasma Instabilities
VELOCITY SHEAR INSTABILITIES IN THE ANISOTROPIC SOLAR WIND AND THE HEATING OF IONS PERPENDICULAR TO THE MAGNETIC FIELD
S. Migliuolo (High Altitude Observatory, National Center for Atmospheric Research, Boulder, CO, 80307)

The linear and quasilinear theory of perturbations in finite-β, collisionless plasmas, that incorporate a sheared velocity flow, is developed. A simple, one-dimensional magnetic field geometry is assumed to adequately represent solar wind conditions near the sun, i.e. at R ≈ 0.3 AU. Two modes are examined in detail: an ion-acoustic mode (finite-β stabilized) and a compressional Alfven mode (finite-β threshold, high-β stabilization). The role played by equilibrium temperature anisotropies, in the linear stability of these modes, is also presented. From the quasilinear theory, the effects of waves on the state of temperature components (parallel and perpendicular to the magnetic field) of the solar wind is determined: qualitative agreement with the observed anisotropies of electrons and ions is obtained. The quasilinear temperature changes are shown to result in saturation of these instabilities.
J. Geophys. Res., Blue, Paper 3A1522

5755 Interactions between solar wind and magnetosphere
NONLINEAR EVOLUTION OF MAGNETOPAUSE TEARING MODES
F. V. Coroniti (Physics Department, UCLA, Los Angeles, California 91604) and K. B. Quest

Since the magnetosheath plasma is highly turbulent, reconnection at the dayside magnetopause is likely to be temporally unsteady. The tearing mode can be viewed as a model for the unsteady development of a reconnecting magnetic topology. Magnetopause tearing occurs in the guide-field limit, and has a wave packet spatial structure in the east-west direction. We solve for the nonlinear evolution a single wavelength guide-field tearing mode including the effects of finite transit time on the Landau resonant electrons. Short wavelength modes evolve algebraically in time with perturbation amplitudes proportional to t^2. Long wavelength modes are fully nonlinear, and the amplitude grows linearly in time. (Magnetopause, reconnection)
J. Geophys. Res., Blue, Paper 3A1546

5770 Short-period (less than 1 day) variations of magnetic field
A REEXAMINATION OF ATS 6 MAGNETOMETER DATA FOR RADIALLY POLARIZED Pc 3 MAGNETIC PULSATIONS
Kazuo Takahashi and Robert L. McPherron (Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California, 90024)

The polarization of Pc 3 (22-100 milliHertz) magnetic pulsations measured by the ATS 6 fluxgate magnetometer at synchronous orbit has been examined using dynamic autospectral analysis. In contrast to the result obtained by Arthur et al. (1977) using the same data set, we find very few cases of radially polarized Pc 3 pulsations. We argue that satellite noise in the radial component, which depends on frequency f as 0.015/f (nT^2/Hz) is responsible for this disagreement. In the presence of this type of noise, diagonalization of the spectral matrix can produce an erroneous major axis of polarization. Most Pc 3 pulsations classified as radially polarized by Arthur et al. appear to be a consequence of small-amplitude azimuthal pulsations contaminated by satellite noise. (Pulsation, magnetic field, polarization analysis).
J. Geophys. Res., Blue, Paper 3A1476

5785 Whistlers
ELF EMISSIONS AND RELATIVISTIC ELECTRON PRECIPITATION
R. H. West (Geophysics Program, University of Washington Seattle, WA 98195), G. K. Parks

Simultaneous measurement of ELF emissions and bremsstrahlung X-rays were made using a balloon-borne experiment flown from Fairbanks, Alaska, on September 30, 1976. Several intense auroral X-ray bursts of 2-3 minute duration were detected which have been interpreted to be the result of relativistic electron precipitation (REP). Simultaneously, the intensity of ELF emissions increased and was also observed to have periodicities similar to those in the X-ray flux. These combined measurements are evidence of magnetospheric wave-particle processes contributing to electron precipitation. The presence of pulsations in the precipitating flux is the only report of this nature during relativistic precipitation. The data have been compared with precipitation and modulation theories and we note that the data agree with a model in which ULF modulation of the emission growth rate occurs. It is postulated that this REP event resulted from ELF wave and electron interaction, possibly triggered by the ULF occurrence rather than directly by ULF-electron interactions.
J. Geophys. Res., Blue, Paper 3A1524

5785 Whistlers
WHISTLER INDUCED SUPPRESSION OF VLF NOISE
W. B. Gail (Space, Telecommunications and Radioscience Laboratory, Stanford University, Stanford, California, 94305), D. L. Carpenter

New evidence has been found connecting whistlers with transient reductions in the amplitude of magnetospheric VLF noise bands. Until now, the only reported examples of such effects were observed during a several hour period at Siple Station, Antarctica when bursts of particle precipitation were correlated with whistlers that suppressed a background hiss band. Data acquired at South Pole Station during 1981 showed similar suppression events on 20% of all winter days. A review of data from Siple, Byrd, Eights, and Palmer Stations in Antarctica and Roberval in Quebec, Canada has since identified many more events. The ground signature of an event is characterized by the attenuation of an existing VLF noise band following the arrival of a whistler. The attenuation typically reaches a maximum of 3-5 dB in 5-10 seconds and the noise band recovers to the pre-event amplitude 15-30 seconds after the whistler. The noise bands are generally mid-latitude hiss, but suppression associated with polar chorus has been seen. Regularly observed features of suppression events include: multi-hop echoing of the driving whistler; confinement of the whistler echoes to the frequency band occupied by the suppressed noise; suppression during the first pass of the whistler; continuing suppression by the whistler echoes as the suppressed noise amplitude reaches a minimum and then recovers; recovery of the noise band to the pre-event level. Event duration was found to increase with the duration of the whistler echo train. Some data suggest that this phenomenon may be a natural analog of the previously reported Quiet Band effect in which signals from the VLF transmitter at Siple Station were observed to attenuate portions of noise bands. (VLF hiss, whistler-mode echoing)
J. Geophys. Res., Blue, Paper 3A1547

5799 (General)
ALBEDO OF SOOT-CONTAMINATED SNOW
P. Chýlek (National Center for Atmospheric Research, Boulder, Colorado, 80307), V. Ramaswamy and V. Srivastava (graphitic carbon).

We present a new model of snow including impurities (graphitic carbon). Submicron soot particles are supposed to be distributed randomly throughout the volume, or at least throughout a surface layer of a snow crystal. Using the mixing rule for a dielectric constant of a composite medium we calculate the refractive index of a snow-soot mixture. Then we proceed to obtain the single scattering albedo and asymmetry factor. Using the delta-Eddington approximation we determine reflectivity (albedo) of a snow layer in the wavelength range 0.3μm ≤ λ ≤ 2.5μm. Calculated spectral albedos as well as the deduced amount of graphitic carbon is in good agreement with field measurements. (Snow, albedo, graphitic carbon)
J. Geophys. Res., Green, Paper 3C1477

5799 General (Ionosphere)
ON THE EQUATORIAL CONFINEMENT OF THERMAL PLASMA GENERATED IN THE VICINITY OF THE RINGS OF SATURN
W.-H. Ip (Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, Federal Republic of Germany)

Consideration of the force balance of the ring plasma generated by meteoroid impact in the rotating ionosphere of Saturn is extended to include the magnetic mirroring effect. It is found that there are modifications to the so-called siphon flow limit derived for charged particles with zero magnetic moment if the ionospheric plasma has a thermal temperature exceeding a few eV. The nature of the force balance is such that, instead of a sharp division between complete loss and complete reabsorption, a transition zone of partial loss appears. If some of the ions near the rings are produced by ionization of the neutral atmosphere in the vicinity of the ring system (also generated by meteoroid impact vaporization), another theoretical limit dividing the upward flow from the equatorially confined motion is located near the observed boundary between the B ring and the C ring. This new limit is very sharp as required to explain the B-C ring boundary, which has not yet been explained by gravitational theory.
J. Geophys. Res., Blue, Paper 3A1421

5799 General (Radiation From Electron Beams)
RADIATION FROM PULSED ELECTRON BEAMS IN SPACE PLASMAS
K. J. Harker (Space, Telecommunications, and Radioscience Laboratory, Stanford University, Stanford, California 94305) and P. M. Banks

A theoretical study has been made of the electromagnetic radiation arising from pulsed electron beams by coherent spontaneous emission. The study assumes an electron beam which has a well organized spatial structure determined by a fixed trajectory in a magnetic field and on/off pulsing governed by the electron source. From this model the electromagnetic radiation is determined by adding coherently the radiation from each individual electron in the helical stream. The radiation per unit frequency interval is determined, as well as the radiation per unit solid angle, as a function of both propagation and ray angles, electron beam pulse width and separation, total number of pulses, and beam current, voltage, and pitch angle. As expected for a coherent process, it is found that the radiated power varies as the square of the beam current. The relatively high efficiency of the beam in producing electromagnetic radiation is illustrated by considering, among others, of a 1 keV, 100 mA beam used in recent experiments on the space shuttle. For these parameters the total radiated power per steradian is calculated at selected angles to be greater than 1% of the total beam power carried as electron kinetic energy. These results provide a useful theoretical basis for planning future electron beam experiments in space plasmas. (Radiation, electron beams, space plasmas, coherent emission).
Rad. Sci., Paper 3S1433

Physical Properties of Rocks

6110 Physical Properties of Rocks
BULK THERMOELASTIC ATTENUATION OF COMPOSITE MATERIALS
B. Budiansky (Division of Applied Sciences, Harvard University, Cambridge, Massachusetts 02138), E. E. Sumner, Jr. and R. J. O'Connell

A theoretical derivation is made for the effective, frequency-dependent thermoelastic bulk modulus $K^*e^{i\omega t}$ of an isotropic composite subjected to hydrostatic stress $\bar{\sigma}e^{i\omega t}$, producing volumetric strain $\bar{\theta}e^{i\omega t}$. No heat transfer is permitted to occur at the outer boundary of the composite, but as a consequence of differential heating, heat transfer among the constituents, and hence dissipation, occurs in the interior. Thus between the limits ω=0 and ω=∞, $K^*(\omega)$ is complex and the thermoelastic damping may be measured by $Q_K^{-1} = Im(K^*)/Re(K^*)$. Parametric studies show the influence of various elastic and thermal properties on thermoelastic damping. Numerical calculations are made for a hypothetical lower-mantle assemblage of stishovite and magnesiowüstite. The results show that thermoelastic dissipation in the lower mantle can account for the observed attenuation of the fundamental radial normal mode, and can also provide interesting constraints on grain sizes. (Bulk attenuation, composite rocks, thermoelastic attenuation).
J. Geophys. Res., Red, Paper 3B1450

6110 Elasticity, Fracture, and Flow
POINT DEFECT CHEMISTRY OF MINERALS UNDER A HYDROTHERMAL ENVIRONMENT
B.E. Hobbs (Earth Sciences Department, Monash University, Clayton, Victoria, 3168, Australia)

The kinetics of rock/water interactions are sufficiently rapid that most hydrothermal systems in nature will be in equilibrium with the adjacent rock mass. The bulk rock chemistry buffers the fugacity of oxygen which in turn fixes the fugacities of water and of hydrogen for a given pressure and temperature. Systems in which only water, oxygen and hydrogen are present as fluid phases are considered here. Variations in the fugacity of oxygen by several orders of magnitude are possible locally, controlled by variations in local rock chemistry; these lead to relative small variations in the fugacity of water.

Incorporation of a hydrogen defect that is capable of acting as an acceptor into silicates leads to a strong dependence of point defect chemistry upon the fugacities of both water and oxygen. The strong dependence on the fugacity of water is capable of explaining the hydrolytic weakening effect but in view of the strong dependence on oxygen fugacity, the question should also be raised whether it is an oxygen effect that is observed in the classical hydrolytic weakening process or solely a dependence on changes in the fugacity of water. Examples are given for impure natural quartz, olivine and albite with trace amounts of calcium.
J. Geophys. Res., Red, Paper 3B1467

6110 Flow of rocks
SODIUM WEAKENING OF HEAVITREE QUARTZITE: PRELIMINARY RESULTS
O. Jaoul (Laboratoire de Géophysique et Géodynamique interne, Université Paris-Sud, 91405 Orsay, France)

The electronic band structure of quartz is altered by the presence of small amounts of impurities such as aluminum, transition metals, alkalies or H_2O. Silicon and oxygen selfdiffusion are enhanced by an increase in the concentration of ionised defects such as charged oxygen vacancies or silicon interstitials due to Na acting as a shallow electronic acceptor. Sodium, by contrast, is a shallow electronic donor and retards the diffusion of these species. To evaluate the effect of the sodium dopant on strength we performed a simple creep experiment (two runs, P=1.5 GPa, T=1073, 1153°K, σ=0.2 to 1 GPa) on Heavitree quartzite (.2 mm grain size) containing 350 ppm at. Na. These doped samples deformed 10 times faster than equivalent undoped ones (at the same stress and temperature). Simple diffusion-control of the creep rate is therefore unlikely but the alternative proposed by Hirsch seems consistent with the data. Using Hirsch's model, the weakening could be interpreted as due to an increase in the dislocation glide velocity through an increase of the charged kink population. This implies electronic transfers are strongly influenced by the nature and the abundance of the impurities (including hydroxyls). Sodium could favour the nucleation of negatively charged kinks. Although this is preliminary and was performed using specimens containing grain boundaries and other impurities (Al), we decided to report it rapidly because of its importance to geology: rocks (like quartzites in this example) not only carry water, but also many different impurities which certainly affect their strengths. (quartz, plasticity, dislocations, impurities, electronic structure).
J. Geophys. Res., Red, Paper 3B1468

6190 Instruments and techniques
STATISTICAL DETERMINATION OF GEOPHYSICAL WELL LOG RESPONSE FUNCTIONS
Eugene A. Nosal (Marathon Oil Company, Denver Research Center, P.O. Box 269, Littleton, CO 80160)

The vertical response function of induction logging tools is shown to be derivable from a power spectrum analysis of the measurement. The vertical response function is the one-dimensional sequence of weights that characterizes how the tool combines the rock conductivities along the borehole to form an output called the apparent conductivity; it is the system impulse response. The value of knowing this function lies in the possible use of filter theory to aid in data processing and interpretation. Two general notions establish the framework for the analysis. The first is that logging is a linear, convolutional operation. Second, the earth's conductivity profile forms a stochastic process. The probabilistic component is fleshed out by reasonably based assumptions about the occurrence of bed boundaries and nature of conductivity changes across them. Brought together, these tenets create a characterization of the conductivity sequence that is not a stationary process, but rather is intrinsic, as defined in the discipline of geostatistics. Such a process is described by a variogram, and it is increments of the process that are stationary. The connection between the power spectrum of the measurement and the system response function is made when the convolutional model is merged with the conductivity process. Some examples of induction log functions are shown using these ideas. The analysis is presented in general terms for possibly wider application.
GEOPHYSICS, VOL. 48, NO. 11

6199 General (Marine Sediments)
THE EFFECTS OF HIGH PRESSURE-HIGH TEMPERATURE ON SOME PHYSICAL PROPERTIES OF OCEAN SEDIMENTS
Roger Morin and Armand J. Silva (Department of Ocean Engineering, University of Rhode Island, Kingston, RI 02881)

A series of laboratory experiments was conducted with four ocean sediments, two biogenic oozes and two clays. Permeability and thermal conductivity were directly measured as a function of porosity and the testing program was designed to identify any dependence of these physical properties upon hydrostatic pressure and temperature. The results show no discernible effect of pressure, within the range of 2 to 60 MPa, upon the permeability of any of the samples. Temperature effects, from 22° to 220° C, upon this property are accounted for by applying a viscosity correction to the permeating seawater. Previous investigations have suggested the existence of a pressure-induced and/or a temperature-induced breakdown of the adsorbed water which surrounds clay particles, thereby producing an increase in sediment permeability. Our experimental findings cannot confirm this phenomenon and fail to provide a satisfactory solution to the conflicting data which now exist between the pore water velocities inferred from non-linear thermal profiles of ocean sediments and those fluid velocities derived from Darcy's law and laboratory permeability data.

The effects of sizeable variations in pressure and temperature upon sediment thermal conductivity are found to closely reflect the behavior of the conductivity of the liquid phase alone under these same changes in environmental conditions. This is not surprising, due to the relatively narrow range of high porosities encountered in this study. Empirical equations are developed which allow sediment thermal conductivity to be calculated as a function of temperature and void ratio. A hydrostatic pressure correction term is also presented.
J. Geophys. Res., Red, Paper 3B1212

Planetology

6510 Atmospheres of planets
MAGNETIC FIELD ORIENTATIONS IN SATURN'S UPPER IONOSPHERE INFERRED FROM VOYAGER RADIO OCCULTATIONS
David P. Hinson (Center for Radar Astronomy, Stanford Univ., Stanford, Ca., 94305)

Dual-wavelength radio observations during the occultations of Voyagers 1 and 2 provided 3.6-cm and 13-cm data on Saturn's ionospheric irregularities at two locations. Spectra of the weak fluctuations in amplitude and phase can be interpreted using the theory for scattering from a power-law spectrum of anisotropic irregularities embedded in a thin screen. Comparisons of measured scintillation spectra with the theory produced least-squares solutions for four parameters which characterize the ionospheric irregularities: (1) the axial ratio, (2) the orientation, (3) the power-law exponent of the spatial spectrum, and (4) the magnitude of the spatial variations in electron density. Scattering was observed from irregularities of approximate size 2-40 km; these lower and upper limits result from noise limitations and the method of analysis, respectively, and do not represent either an inner or outer scale. Within this range of length scales, the three-dimensional spatial spectrum obeys an inverse power law with exponent near 3.6, and the fractional variations in electron density are about 10-20%. All observed irregularities appear to be anisotropic with axial ratios greater than 4:1. Magnetic field orientations in Saturn's ionosphere were inferred from the direction of alignment of the anisotropic irregularities. When used as a test of Saturnian magnetic field models, the occultation measurements generally confirm the accuracy of the model predictions, but also suggest that a small adjustment of model parameters might improve the field representation. (Radio occultations, ionospheric irregularities, magnetic fields).
J. Geophys. Res., Blue, Paper 3A1475

6510 Atmospheres of Planets
POSSIBLE DUST DEVILS, VORTICES ON MARS
J.A. Ryan and R.D. Lucich (Earth Science Department, California State University, Fullerton, Fullerton, California, 92634)

This paper presents the results of a study of local vortices, and dust devils, on Mars as observed by Viking Landers 1 and 2. It is found that these vortices involve wind speeds which may raise dust from the martian surface. There is no indication that these possible dust devils contribute to the planet-wide spread of major dust storms. However, it appears that they may help in maintaining the atmospheric dust content. The data indicate that there is no preference in rotation direction, at least to core diameters of 309 m (corresponding to a region of influence of about 1 km diameter). (Mars atmosphere, dust devils, vortices).
J. Geophys. Res., Green, Paper 3C1514

6540 (Interior Of Moon)
AN UPPER BOUND ON THE RADIUS OF A HIGHLY ELECTRICALLY CONDUCTING LUNAR CORE
S. I. Hobbs, L. L. Hood, F. Herbert, and C. P. Sonett (Lunar And Planetary Laboratory, University Of Arizona, Tucson, Arizona 85721)

Abstract. Parker's [1980] nonlinear inverse theory for the electromagnetic sounding problem is converted to a form suitable for analysis of lunar day-side transfer function data by (1) transforming the solution in plane geometry to that in spherical geometry; and (2) transforming the theoretical lunar transfer function in the dipole limit to an apparent resistivity function. The theory is applied to the revised lunar transfer function data set of Hood et al. [1982a] which extends in frequency from 10^{-5} to 10^{-3} Hz. On the assumption that an iron-rich lunar core, whether molten or solid, can be represented by a perfect conductor at the minimum sampled frequency, an upper bound of 435 km on the maximum radius of such a core is calculated. This bound is somewhat larger than values of 360-375 km previously estimated from the same data set via forward model calculations because the prior work did not consider all possible mantle conductivity functions. (Conductivity, core, induction, magnetic fields).
J. Geophys. Res., Red, Paper 3B5116

6545 Meteoritics
IMPACT VERSUS INTERNAL ORIGINS FOR MESOSIDERITES
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Abstract. Mesosiderites are very intimately mixed stony-iron breccias, including little recrystallized and highly recrystallized varieties (I-III) and a subgroup (IV) with melted matrix. All mesosiderite breccias contained some material that was hot, as indicated by pigeonite that inverted at 1150°C. Subgroup IV contained silicate and metal liquids at temperatures of at least 1300°C and 1350°C, respectively. Cooling rates are not rigorously defined, but are approximately 1°/year in the high temperature range and 1°/m.y. below 500°C. The latter cooling requires a depth of 40 km in an asteroid with a radius of 400 km, or less if porous, low-conductivity surface material is present. Cratering with metal projectiles appears incapable of generating mesosiderites: a normal impact in forms rapidly cooled, metal-poor breccias. Impacts into a crust in which metal-silicate segregation had taken place could generate stony-iron breccias, but burial under an insulating blanket would be necessary to obtain slow cooling. Disruption and reassembly of two colliding bodies and accretion of differentiated planetesimals could form stony-iron breccias at depth but, as with the previous two models, the easiest way to explain the low olivine of mesosiderites is to postulate derivation from olivine-poor chondritic material. Two internal processes, turbulent metal-crust mixing during core formation and crustal blocks sinking into the core, provide a deep location and withhold olivine from the breccia. However, these mechanisms do not explain how the silicate and metal liquids in subgroup IV (otherwise interpreted as impact melt-rocks) could have failed to segregate in a deep, slowly cooled environment. No single model for mesosiderite origins is wholly satisfactory.
J. Geophys. Res., Red, Paper 3B5046

6560 Meteoritics
CHEMICAL AND PHYSICAL STUDIES OF TYPE 3 CHONDRITES: 2. THERMOLUMINESCENCE OF SIXTEEN TYPE 3 ORDINARY CHONDRITES AND RELATIONSHIPS WITH OXYGEN ISOTOPES
Derek W. G. Sears (Chemistry Department, University of Arkansas, Fayetteville, Arkansas 72701), Karun S. Weeks

Thermoluminescence (TL) sensitivity values for sixteen type 3 ordinary chondrites, fourteen of them from Antarctica, have been measured. The values obtained (normalized to the TL sensitivity of the Dhajala meteorite) range from 1.6 (Allan Hills A77216) to 0.010 (Allan Hills A77214), and include two (Reckling Peak A80207 and Allan Hills A77176) that are particularly low. They fill a hiatus in the TL distribution that previously existed between St. Mary's County and Bishunpur, the latter being a meteorite with one of the lowest TL sensitivities known. The histogram of TL sensitivity values now shows a single distribution with higher values preferred; it resembles the histogram for L chondrites occupying the petrologic types 3, 4, 5, and 6. There is a tendency for the TL sensitivity of meteorites to decrease as $\delta^{18}O$ increases; equilibrated meteorites have TL sensitivities of 5-50 and $\delta^{18}O$ = 4.5 to 5.0‰, while the most primitive meteorites with TL < 0.01 have $\delta^{18}O$ = 5.7 to 6.2‰. Meteorites with intermediate TL have intermediate $\delta^{18}O$. Theoretically it is possible that the range of $\delta^{18}O$ values observed may reflect progressive loss of O in the form of CO at very low temperatures, but very restrictive physical conditions and a complex history seem to be required. (Thermoluminescence, oxygen isotopes, Type 3 ordinary chondrites, metamorphism).
J. Geophys. Res., Red, Paper 3B5021

6560 Meteoritics
A THREE-DIMENSIONAL STUDY OF METAL GRAINS IN EQUILIBRATED, ORDINARY CHONDRITES
John Willis and Joseph I. Goldstein (Dept. of Metallurgy and Materials Engineering, Lehigh University, Bethlehem, Pennsylvania, 18015).

Metal particles in Guareña (H6), Colby (L6) and St. Severin (LL6) were studied by optical microscopy and by electron microprobe analysis. Observations from successive polished sections through the metal particles show that kamacite and taenite grains, which often appear to be isolated particles, are connected directly or by intervening sulfides. Also tetrataenite rims are widest when adjacent to sulfide or kamacite. These observations indicate that transfer of Ni during cooling when kamacite-taenite phase growth takes place does not occur through the silicate phases but proceeds through metal and sulfide phases or along grain boundaries. By utilizing the central Ni content of taenite grains from successive sections, metallographic cooling rates were determined more precisely than by using one arbitrary section. Cooling rates determined in this manner for Guareña, Colby, and St. Severin are 4.1 K $m.y.^{-1}$, 4.0 K $m.y.^{-1}$, and 1.0 K $m.y.^{-1}$, respectively. (Chondrites, metal, cooling rates.)
J. Geophys. Res., Red, Paper 3B5011

6560 Meteoritics
^{26}Al-PRODUCTION RATES AND ^{53}Mn/^{26}Al PRODUCTION RATE RATIOS IN NONANTARCTIC CHONDRITES AND THEIR APPLICATION TO BOMBARDMENT HISTORIES
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The long-lived spallogenic radionuclides ^{26}Al and ^{53}Mn were systematically studied in a large number of nonantarctic meteorites by nondestructive γ-γ-coincidence technique and neutron activation, respectively. From the ^{26}Al-activities normalized to the main target element, silicon, an average production rate of 299 ± 55 (dpm/kg Si_{equ}) was derived. Based on 19 chondrites with exposure ages ≥ 12 x 10^6a and depth profiles of Bourma and Feyes, an average production rate ratio [^{53}Mn/^{26}Al]$_{prod}$ = 1.40 ± 0.15 [dpm/kg Fe / dpm/kg Si_{equ}] was calculated, which seems to be depth-independent for meteorites with preatmospheric radii R ≤ 35 cm. ^{53}Mn/^{26}Al radiation ages for 25 stones with short exposure ages were determined. A comparison of our results with the respective ^{53}Mn- and ^{21}Ne-exposure ages generally shows a good agreement. The cosmic ray bombardment age scale covered by this method is 1 x 10^6 < T_{rad} < 10 x 10^6a. (Chondrites, cosmogenic radionuclides, production rates, production rate ratios, exposure ages).
J. Geophys. Res., Red, Paper 3B5001

6560 Meteoritics (Enstatite Chondrites)
IMPACT MELT-ROCK CLASTS IN THE HVITTIS ENSTATITE CHONDRITE BRECCIA: IMPLICATIONS FOR A GENETIC RELATIONSHIP BETWEEN EL CHONDRITES AND AUBRITES
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The Hvittis enstatite chondrite breccia contains 512 vol% dark clasts which appear to be impact melt-rocks. The largest clast (Clast A) is 2.5 cm in diameter; it has an igneous texture, no chondrules, and is depleted in metallic Fe,Ni and sulfide. Its fine grain size, low-Ni kamacite and schreibersite, and rare martensite resulted from rapid cooling. The abundance of melt-rock clasts in Hvittis suggests that the breccia resided at its parent body surface. However, the apparent absence of EL chondrites with solar wind-implanted rare gases suggests that the EL parent body was too small to develop a substantial regolith. The bulk composition of Clast A is very similar to that of average aubrites, except for a seven-fold enrichment of S, Cr, and Mn. These elements are concentrated in the sulfides. It thus is possible that the clast was derived from one of the sulfide-rich regions of the Hvittis matrix. If so, then aubrites may be genetically related to EL chondrites. (Breccia, aubrites, impact melt-rocks).
J. Geophys. Res., Red, Paper 3B5008

6560 Meteoritics
EXPERIMENTAL STUDY OF SEGREGATION IN PLANE FRONT SOLIDIFICATION AND ITS RELEVANCE TO IRON METEORITE SOLIDIFICATION
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A directional solidification technique was developed and applied to the problem of fractional crystallization of an iron meteorite parent body. Samples of Fe-Ni alloys close to meteorite compositions, and containing S, P, and C were made. The solidified structures contain secondary phases such as sulphides within the proeutectic single crystal austenite (taenite). As a result of these experiments, we propose that the secondary phases observed in iron meteorites were formed during primary solidification of austenite (taenite). The measured composition profiles of Ni, P and C in the alloys were used to explain the elemental distribution within a chemical group of iron meteorites. An analytical procedure was applied to determine the equilibrium distribution coefficient as a function of fraction solidified for Ni and P from the composition profiles. The distribution coefficients of Ni and P agree with previous values. These distribution coefficients are of particular interest in the determination of the elemental distributions in iron meteorites. (Distribution coefficients, Iron meteorite, directional solidification.)
J. Geophys. Res., Red, Paper 3B5010

6599 General
PIECES OF THE ANCIENT LUNAR CRUST: AGES AND COMPOSITION OF CLASTS IN CONSORTIUM BRECCIA 67915
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We discuss the composition and chronology of clasts representing three minor lithologies in consortium breccia 67915. The lithologies studied are: sodic ferrogabbro, pristine troctolitic anorthosite (67915,26), and granulitic troctolitic anorthosite (67915,67). These lithologies were presumed to represent samples of the ancient lunar crust. The pristine troctolitic anorthosite, a typical member of the pristine anorthosite suite, contains little or no trapped liquid consistent with its two-phase mineralogy. The plagioclase separates have ^{39}Ar-^{40}Ar plateau ages of 4.10 ± 0.06 b.y., and a final rise in the age pattern may represent a 'memory' of the earlier evolution. The granulitic troctolitic anorthosite, which has 13 times larger REE abundances, displays a continuous rise of the $^{40}Ar/^{39}Ar$ ratio. The last 25% of the ^{39}Ar release data establish a minimum age of > 3.5 b.y., but the ^{244}Pu/Nd chronology suggests an age of ~4.1b.y. The sodic ferrogabbro samples, which appear to be members of the Mg-gabbronorite group of pristine rocks, show large Ar losses but indicate plateaus in the low-temperature data, suggesting a metamorphic event more recently than 260 m.y. ago, a time that is consistent with the North Ray impact event 50 m.y. ago.
J. Geophys. Res., Red, Paper 3B5054

Seismology

6950 Seismic Sources
CONSTRAINTS ON PLATE MOTIONS IN SOUTHERN PAKISTAN AND THE NORTHERN ARABIAN SEA FROM THE FOCAL MECHANISMS OF SMALL EARTHQUAKES
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The focal mechanism and depth were determined for nine small earthquakes (M_0 < 10^{25} dyne-cm, M < 5.5) that occurred in southern Pakistan and the northern Arabian Sea from an analysis of the vertical component of Rayleigh waves in combination with limited first-motion data. Focal parameters were determined from the Rayleigh waves by using an event-pair method of analysis. For earthquakes that are located very close to each other (< ≈ 50 km), the event-pair method is able to remove a significant proportion of propagation effects at all periods in the range of interest (20-50 sec). For events separated by more than ≈ 100 km the propagation effects are reduced for only the longer periods (≈40-50 sec). The earthquakes that were studied provide evidence for a model of plate interactions in the vicinity of the southern Pakistan triple junction. The Owen fracture zone is a transform fault that accommodates right-lateral motion between the Indian and Arabian plates. The plate boundary in the vicinity of the Murray ridge is also partially made up of transform segments that strike subparallel to the Owen fracture zone. Spreading centers may also exist in the vicinity of the Murray ridge, but were not documented by seismic or other evidence. The slip azimuths for earthquakes along this boundary are significantly more northerly than those predicted by various regional and world-wide models of plate motion. The Arabian plate is being subducted beneath the Eurasian plate along the southern coast of Pakistan. Slip vectors for earthquakes along this boundary trend north-northeasterly in general agreement with predicted directions. Left-lateral motion is documented along the boundary between the Indian and Eurasian plates in southern Pakistan. The predicted direction of relative motion between these plates is not significantly different from that observed. Two of the earthquakes studied appear to be intraplate in nature. The depth and focal mechanism of one intraplate event, which may have occurred within the accretionary prism along the Makran coast, however, is based on limited data. The other intraplate earthquake occurred within sedimentary deposits along the western edge of the Indian subcontinent near the Indian-Eurasian plate boundary. (Surface waves, Pakistan, tectonics)
J. Geophys. Res., Red, Paper 3B1511

8950 Seismic Sources
LINEAR MOMENT TENSOR INVERSION FOR SHALLOW THRUST EARTHQUAKES COMBINING FIRST-MOTION AND SURFACE WAVE DATA
Andrew J. Michael (Department of Geophysics, Stanford University, Stanford, California, 94305) and Robert J. Geller

We derive a linear moment tensor inversion method (which we call second nodal plane inversion) for obtaining a double couple for mechanism when one nodal plane is known. This typically is the case for shallow thrust events, for which only the steeply dipping nodal plane can be determined from teleseismic first motions, conventional moment tensor inversion methods are known to fail for these events because the portion of the moment tensor corresponding to vertical dip-slip faulting is extremely inefficient in exciting surface waves. In this paper we invert long period (256 sec) fundamental mode Rayleigh waves from the IDA network; the inversion technique can also be applied to body wave amplitude data or to entire records (as a sum of normal modes), given the appropriate normal equations.

We study several shallow (h < 35 km) thrust earthquakes for which the steeply dipping nodal plane can easily be found from body wave first motions. In contrast to standard surface wave moment tensor inversion techniques, which have serious stability problems for such shallow events, our technique successfully finds the scalar moment and second nodal plane. (Seismic sources, surface waves, instruments and techniques).
J. Geophys. Res., Red, Paper 3B1510

Social Sciences

7310 Economics
ESTIMATING DEMAND FOR INTAKE WATER BY SELF-SUPPLIED FIRMS
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The proper specification of price variable in estimating the demand for intake water by self-supplied firms is a neglected subject in the literature. Previous studies have used measures of average cost, but neoclassical economic theory suggests firms respond to marginal costs. Using data from a sample of paper and chemical firms in Arkansas the null hypothesis that there is no significant difference in the estimates of industrial water demand using either average or marginal costs is tested. It is shown that the use of average cost provides a better estimate of water use in terms of statistical fit and predictive capabilities. (Industrial water demand).
Water Resour. Res., Paper 3W1615

Solar Physics, Astrophysics, and Astronomy

7720 Electromagnetic Radiation
ESTIMATING THE VARIABILITY OF THE SOLAR FLUX BETWEEN 200 AND 300 NM
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Observations of the solar ultraviolet irradiance during 1979 (solar maximum) by the Solar Backscatter Ultraviolet experiment on the Nimbus 7 satellite have established that the irradiance at wavelengths between 200 and 300 nm is modulated by solar rotation. This short term variability, which is of the order of 3% at 200 nm and 1% at 250 nm, is associated with the evolution and rotation on the solar disc of plage areas which are enhanced in ultraviolet emission. By using ground based Ca II K observations of the fraction of the disc covered by plage during 1979, the intensity ratios for plage to quiet sun emission at these wavelengths have been derived. During the 11 year solar cycle the number of plage regions on the solar disc increases. As well, there is an accumulation of active network arising from the remnants of decayed magnetic features. A three component model of the solar irradiance is used to estimate the temporal behaviour of the ultraviolet emission between 200 and 300 nm, resulting from changes throughout the solar cycle in the active features on the disc. These calculations suggest that for solar cycle 21 the flux variability at 200 nm is 25%, decreasing to 10% at wavelengths between 210 and 250 nm, and to 2% at 300 nm. Ultraviolet flux variability of this magnitude corresponds to an average increase in the total solar irradiance from 1976 to 1979 of about 0.05%. For comparison, the average reduction in the total solar irradiance from 1976 to 1979 due to sunspot blocking is 0.07%. Because of the enhanced ultraviolet emission from solar active features, the variability of the total solar irradiance during cycle 21 is predicted to be less than is calculated by models which consider only the effects of sunspot blocking. This result is consistent with the need for an added faculae brightening term in total solar irradiance models.
J. Geophys. Res., Blue, Paper 3A1571

Volcanology

8499 Volcanology topics
ERUPTION FORECASTING AT KILAUEA VOLCANO, HAWAII
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Data from a network of seismometers, a tiltmeter and the pattern of summit inflation between eruptions have made qualitative eruption forecasting possible on Kilauea volcano for over 20 years. This paper formulates quantitative forecasting by calculating the probability of an eruption based on current levels of tilt, tilt rate, seismicity, and fortnightly tide. Plots of eruption probability as a function of various parameters are derived using a set of 29 eruptions during 1959-79. The method tests the precursory significance of various parameters over different time scales and determines probabilities by comparing data before eruptions with data values generally. Tilt level is an eruption precursor significant to better than 99.9% when averaged over any interval from 1 to 20 days. Tilt rate is a precursor significant to better than 99.999%, but noise in the data requires that it be averaged over 10 days or more. Earthquakes are a short-term precursor significant to better than 99% when averaged over 1 to 10 days for larger earthquakes near the summit caldera, and over 5 to 20 days for very small earthquakes within the caldera. The fortnightly modulation of tides influences eruption probability and has a precursory significance of 97%. Probabilities are independent of the time elapsed since the last eruption. The eruption probability, when tested against the eruption record from which it was derived, is significant to the 99.98% level when compared with random guessing. Ongoing 1-day, 7-day, and 30-day forecasts are calculated by computer at the Hawaiian Volcano Observatory and supplement the qualitative interpretation of geophysical data.
J. Geophys. Res., Red, Paper 3B1580

General or Miscellaneous

9840 Techniques applicable in more fields
MAXIMUM ENTROPY SPECTRAL ANALYSIS OF ARTIFICIAL SINUSOIDAL SIGNALS
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We applied the Burg's algorithm to the spectral analysis of a signal which is the sum of 11 sinusoids as intermixed with different noise levels. We paid particular attention to those features which for single sinusoids represent the crucial point of this technique and found that, for a multicomponent signal, the frequency shiftings are smaller than for single sinusoids and the splitting phenomena tend to occur at much higher orders of the prediction error filter. For a noise power smaller than 17% of the power of the lowest amplitude component, all the expected peaks were easily identified and most of the power was concentrated in very narrow ranges of frequency. The behavior of the final prediction error might provide useful suggestions only for higher noise levels and the choice of the limits for the application of the Akaike's criterion is ambiguous and strongly dependent on the noise level. An analysis of individual signal components does not confirm the results of previous investigations in that the splitting hierarchy appears independent on the wave parameters. We also examined the effects of the progressive addition of new components and found that it progressively leads to smaller frequency shifts and higher orders of appearance of splitting phenomena. (Maximum entropy, spectral analysis).
J. Geophys. Res., Blue, Paper 3A1211